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USSR Report

ENGINEERING AND EQUIPMENT

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AERONAUTICAL AND SPACE

AN-124 AIRPLANE'S CARGO-HANDLING AND AUTOMATION EQUIPMENT

Kiev PRAVDA UKRAINY, 26 May 85 p 1

KUZNETSOVA, T.

[Excerpt] The 36th International Aviation and Space Technology Show opens on May 29 at Le Bourget Airport. This airport, which is in a suburb of Paris, is comparatively small by present-day standards. Among the exhibits will be a new aircraft developed at the Design Bureau imeni Antonov.* This event was the subject of a press conference held at the design bureau before the airplane's departure for Paris.

General aircraft designer Petr Vasil'yevich Balabuyev told journalists:

"This is the 10th time we have exhibited our aircraft in Paris. This time we shall show a new development: the wide-body transport airplane AN-124, or 'Ruslan', as Oleg Konstantinovich Antonov called it. Not without reason did this aircraft receive the legendary hero's name; its dimensions are without precedent in aviation: height -- 22 meters; length -- more than 70 meters; body width -- 7.5 meters.

"We sought to develop an aircraft with a large payload capacity and much cargo room, for transporting cargo items that cannot even be delivered by rail. And this was achieved: the AN-124 can take 150 tons on board. The airplane flies at a speed of 800-850 kilometers per hour at an altitude of 10-12 kilometers. The 'Ruslan' consumes one-third as much fuel per unit of work as the 'Antey' [AN-22] does. The AN-124 operates from airfields 3,000 meters long, but they do not have to be concrete ones. The airplane's multistrut landing gear with adjustable height ensures safe flights from dirt runways, too."

"The main job of the 'Ruslan' is to deliver cargo. How is it adapted for this?"

"Optimally. The airplane has two hatches -- a front one and a rear one -- and also an onboard loading equipment complex. Fast and convenient loading of the aircraft is made possible by two traveling cranes with a lifting capacity

* See also the Daily SNAP, June 7, 1985, p. 1, col. 1; and p. 3, col 2

of 10 tons each, two winches with a capacity of 3 tons each, and a complex consisting of roller-conveyer and mooring equipment and a 'squatting' system.

"Our new 'AN' is distinguished by more than just size and cargo capacity. Unique dimensions were used in its structure, as well as a large amount of composite materials and other latest achievements of Soviet science and technology. Thanks to this, many of the airplane's parameters surpass those of its foreign counterparts. It has none in the literal sense, of course; the capacity of the largest U.S. airplane falls short of our giant's by 30 tons."

"And how have you taken care of the pilots?"

"The airplane is equipped with the latest navigation and piloting equipment, as well as an automated electrohydraulic control system with quadruple redundancy, which ensures a high degree of reliability.

"The AN-124 is equipped with an onboard automatic monitoring complex which oversees the parameters of all of the airplane's systems, compares them and warns ground services in the event of a malfunction, enabling them to prepare for receiving the aircraft and eliminating the defect."

FTD/SNAP

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CSO: 1861/282

AN-124 FLIES FROM KIEV TO PARIS AIR SHOW

Moscow KOMSOMOL'SKAYA PRAVDA, 29 May 85 p 1

STEL'MASHEV, K., correspondent

[Text] Kiev, May 28 -- The AN-124 giant air transport, which was developed at the Design Bureau imeni Antonov, departed today for Paris, to the International Aviation Show at Le Bourget.

The "Ruslan", as this mighty machine has been nicknamed, can carry 150 tons of cargo. This is twice the payload of its renowned predecessor "Antey", which was the world's first wide-body airplane and which was a sensation at Le Bourget 20 years ago.

Compact lines conceal the true dimensions of the airplane. They are impressive. Two "Ikarus" [buses] can easily drive through the tail hatch, for example. The cargo bay is 36 meters long, 6.4 meters wide and 4.4 meters high. It easily accommodated, in two rows, one of these buses, two heavy fire trucks, a "KamAZ" vehicle, and a "K-700" tractor. Driving straight through the airplane, these vehicles descended down a wide ramp onto the runway. The fold-up nose section of the fuselage made such a maneuver possible.

General designer P. Balabuyev related: "The AN-124 can handle deliveries of approximately 80 percent of all large cargo items that are needed in the North and in other rapidly developing regions of the country. The aircraft is intended for intercontinental flights as well. Its flight range with a full payload is 4,500 kilometers, and its maximum range is 16,500 kilometers."

On its first long flight from the banks of the Dnepr to Paris, the airplane was flown by the crew of USSR meritorious test pilot V. Terskiy, who has test flown the aircraft from the beginning.

(Two photographs are given showing the AN-124 in flight, and a column of vehicles lined up at its rear cargo bay entrance.)

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CSO: 1861/282

INFORMATION ON NEW AN-124 GIANT CARGO PLANE

Leningrad TRUD, 23 May 85 p 3

DOMBKOVSKIY, N., correspondent (Kiyev)

[Abstract] The lengthy article describes the impressive dimensions and capabilities of the new AN-124 cargo airplane, which the author toured at a test-flight airfield.*

The AN-124's payload capacity is 150 tons, which is said to be 50 percent greater than any airplane before it. The airplane's own weight is 405 tons. Other specifications and performance figures given for it are: cargo bay--6.5 meters wide, 4.5 meters high, and more than 30 meters long; top speed--850 kilometers per hour; ceiling--12,000 meters; nonstop range--16,500 kilometers. These performance ratings reportedly were confirmed by test flights. The airplane has front and back ramp loading. The nose section of the fuselage opens upward, and there are doors at the rear. The airplane's body can be lowered on the landing gear to facilitate loading. The AN-124 is flown by a crew of six: commander, co-pilot, navigator, radio operator, and two flight engineers. It has sleeping quarters and kitchen and washroom facilities for carrying a reserve crew of six.

The article goes on to praise the work of the airplane's developer, the Design and Experimental Bureau imeni Antonov, which is headed by P. V. Balabuyev, and to characterize the unique nature of solutions that were involved in designing and building it. It is said that in the AN-124, the bureau demonstrated how technology is advanced along a broad front, solving problems of aerodynamics, materials science and computer technology that were not possible to solve by conventional methods. One unique technological solution that is mentioned is that it was decided to make the wing panels in one piece. Since there wasn't a production facility that could do this in Kiyev, the wings, each of which is more than 30 meters long, were made in another city, several thousand kilometers away. It is said the question of how to transport the wings to Kiyev was resolved by Balabuyev, who proposed that they be carried on top of an AN-22 cargo plane. Wind-tunnel tests proved this was possible, and the operation was carried out with an AN-22 that was modified by installing a third verticle tail fin.

* See also the Daily SNAP, May 31, 1985, p. 1, col. 2.

AN-124 GIANT CARGO PLANE ENTERED IN PARIS AIR SHOW

Moscow KOMSOMOL'SKAYA PRAVDA, 23 May 85, p 1

POLOZHEVETS, P. (Kiev)

[Text] The new Soviet transport airplane, the AN-124, will be exhibit No. 318 at the 36th international aerospace show in Paris. It was developed at the renowned Design Bureau imeni Antonov.* Vladimir Terskiy, a meritorious test-pilot of the USSR, will fly this transport giant to Le Bourget. This will not be his first flight to Paris. He exhibited another new aircraft, the AN-22, there 20 years ago.

"Everyone was simply stunned by the airplane at that time," recalled Vladimir Ivanovich. "Unable to believe the stated dimensions of the 'Antey', specialists began stepping off the measurements of the aircraft's shadow. The present AN-124 can indeed be compared with the legendary hero Ruslan. It was nicknamed for him by O. K. Antonov."

Hundreds of scientific organizations and industrial associations and dozens of ministries and agencies took part in the development of this unique aircraft. It will soon come to the aid of oil-industry, gas-industry and construction workers of the Far North and Far East. Containers for maritime shipping, long girders and bridge structures, drilling equipment, heavy tractors and scrapers, motor buses, river vessels, dredgers and pipe-laying machines--there is room for any of these in the airplane's cargo bay. Cargo items can be arranged in a row or in two rows, if you wish. The 'Ruslan' has hatches for front and rear loading. It can land on ordinary dirt airfields and take off from them. Frozen Siberian swamps are also suitable landing places for it.

Scientists and designers managed to circumvent the rule that an airplane's weight grows as its size is increased. The AN-124 incorporates many qualitatively new solutions. Purely aerodynamic ones, for example. Non-metallic materials--so-called composite structures--are broadly utilized for the first time. Employing them, the specialists simultaneously developed technology for producing them.

* See also the Daily SNAP, May 31, 1985, p. 1, col. 2, and June 5, 1985, p. 2, col. 2

Electronics have become the crew's reliable helper. Information provided by an onboard computer about the condition of any of the airplane's assemblies or systems appears on a video terminal, on demand.

Speaking at a press conference yesterday, P. V. Balabuyev, general designer of the design-and-experimental bureau and a laureate of the USSR and Ukrainian SSR state prizes, said that the parameters and quality of the AN-124 surpass those of many of its foreign counterparts.

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DATA ON MI-26 HELICOPTER

Moscow KOMMUNIST, 19 May 85, p 4

CHERNOV, L., deputy head of a department of the State Committee for Science and Technology

[Excerpt] In the opinion of specialists, the new MI-26 helicopter, which was developed at the Design-and-Experimental Bureau imeni Mil', possesses the highest payload capacity in the world. Weighing 28 tons, it can transport large cargo items that weigh more than 20 tons over distances as great as 800 kilometers, in severe climatic conditions.

The helicopter has passed trials. It is now being used with success in the construction of bridges and other structures, and in the delivery and installation of heavy equipment for industrial enterprises and drilling rigs in remote, hard-to-reach areas. It has replaced the 12-ton MI-6, which has been in service for more than 20 years. Equal to the MI-6 in size, the MI-26 possesses twice the power, which has been achieved through the use of new materials and design solutions, and also thanks to two D-136 gas-turbine engines, which are the most economical among engines of this type. The engines have a takeoff power of 1,000 horsepower each. In combination with the improved aerodynamic lines of the helicopter itself, they consume less fuel per ton of cargo. The engines transmit their power to the VR-26 gear, whose design employs a fundamentally new scheme that permits twice as much power and 50 percent more torque to be transmitted to the rotor than in the MI-6.

The rotor of the MI-26 has eight blades and is 32 meters in diameter. Operated by a crew of five, the MI-26 can climb to more than 4,500 meters, and it can hover at altitudes as high as 1,800 meters, as well as right above the ground. The MI-26 is equipped with special air cleaners which are mounted in front of the engine air-intakes and protect the air duct against various particles and small objects.

The power plant has systems for automatically maintaining rotor revolutions and synchronizing engine power; if one of the engines fails, the power of the other is increased to maximum, which increases flight safety.

The MI-26 is simple and reliable to operate. Its design and the arrangement of its systems make ground maintenance possible without special airfield equipment, and an auxiliary power unit ensures prolonged operation of the helicopter on its own, far from its base.

The helicopter is loaded through a hatch in the tail section of the fuselage, which has a ramp that lowers. There is an onboard TV system with three cameras. The first is mounted on the tail boom, permitting the crew to watch loading operations as they sit in the cabin. The second camera gives a view of the rear hemisphere, and the third camera permits the outside sling to be viewed, ensuring accuracy in installation work.

For mechanization of loading operations, the cargo bay is equipped with two electric winches and a hoisting mechanism that load cargo items weighing up to 5 tons each and move them inside the bay. With a length of 15 meters, the cargo bay can easily hold two trucks or two motor buses.

The crew's cabin is roomy and has a good view. Piloting and navigational equipment and an automatic control system permit the MI-26 to fly in any weather conditions, at nights as well as day.

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CONFERENCE ANALYZES MAINTENANCE OF CIVIL AVIATION SYSTEMS

Moscow VOZDUSHNYY TRANSPORT, 30 Apr 85, p 3

[Text] An All-Union Scientific-Technical Conference "Aviation Engineering Support of Flight Safety" ended its work recently at the Moscow Institute of Civil Aviation Engineers (MIIGA). Sponsored by the USSR State Committee for Science and Technology and the Ministry of Civil Aviation, it posed an important goal for participants: determining the status, summing up experience, and formulating important tasks of scientific research in the field of aviation engineering support of flights.

The conference was opened by V. Vorob'yev, president of MIIGA.

Papers were read at a plenary session by I. Mulkidzhanov, head of the USSR Aircraft Register; R. Sakach, head of the State Scientific Research Institute of Civil Aviation; T. Anodina, head of the Scientific and Experimental Center for Automation of Air Traffic Control; and Ye. Kitov, head of the All-Union State Production Association "Aviaremont" (aircraft repair).

The conference's participants analyzed the experience of work on the development and certification of aviation technology, improvement of equipment for air traffic control and navigation, and organizing the operation and repair of airliners. There was a broad exchange of information on results of theoretical and practical work in scientific research organizations, educational institutions, civil aviation administrations and enterprises, and related services.

As a result of the discussion, important tasks of scientific research were defined in the field of aviation engineering support of flight safety.

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ROLE OF OPTIMIZATION METHODS IN IMPROVEMENT OF FLIGHT CONTROL FOR AIRPLANES

Moscow STANDARTY I KACHESTVO in Russian No 12, Dec 84 pp 15-18

KASHIN, G.M., doctor of technical sciences, professor, and FEDORENKO, G.I.,
doctor of technical sciences, professor

[Abstract] While conventional computer-aided automatic flight control alone improves the static and dynamic characteristics of airplanes, active automatic control can further improve the flight mechanics by such means as reduction of takeoff mass. Such a control system is capable of performing other new additional functions as well, namely relaxing the constraints on "natural" static stability, reducing the loads involved in maneuvers, increasing the stability margin under flutter, damping elastic vibrations in a turbulent atmosphere, direct control of lift and lateral forces, improving the flight aerodynamics, prevention of dives and spins, and improving passenger comfort. The stability margin is reduced by increasing the stability level. Maneuvers in the vertical plane under a given overload are done by tilting the control surface for optimum redistribution of aerodynamic forces over the wing span and thus with smaller bending moments on the wings. Active suppression of flutter and vibrations is preferable to passive suppression, because it does not require adding mass and increasing critical dimensions; also the load during flight through a turbulent atmosphere can be actively controlled for maximum fuel economy, and active control of interceptors can be optimized for fast response to error correction during descent so as to ensure a soft landing. Automatic control of passenger comfort is an outstanding new feature which illustrates the capability of automatic control systems in aviation technology. The design of such a system is based on analysis of surges and vibrations, requires inclusion of corrective filters, and calls for a new approach to optimization of the control algorithm for this new special application. One approach proposed is the approach taken for optimizing the parameters of standardization objects. Figures 2; references: 7 Russian.
[177-2415]

ACOUSTIC FIELD OF DIRECTIONAL SOURCE IN OCEANIC WAVEGUIDE

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 280, No 1, Jan 85 (manuscript received 13 Jul 84) pp 57-59

BYKOVTSSEV, G.I., KUZNETSOV, G.N. and STEPANOV, A.N., Kuybyshev State University

[Abstract] The acoustic field of a directional monochromatic sound source for oceanic research is described on the basis of an equivalent point source with arbitrary orientation. This model is particularly convenient for determining the hydroacoustic field distribution in a waveguide between the seabed and a free surface. The calculations are made by solving the external Dirichlet problem for the corresponding Helmholtz equation in spherical coordinates under appropriate boundary conditions. The simplest case is that of ideal boundaries. For nonideal boundaries one can modify the equation in accordance with the model of a waveguide resting on a liquid half-space. The solution is unique in each case. The multipole moments characterizing the directionality of a real sound source are then determined from measurements, upon minimization of the maximum-likelihood functional based on the equivalent point source. Article was presented by Academician V.I. Ilichev on 13 May 1983. References: 3 Russian.
[155-2415]

NUCLEAR ENERGY

MATHEMATICAL MODELING IN DESIGNING OF NUCLEAR TURBINES

Kiev PRAVDA UKRAINY, 16 Apr 85, p 3

KHABINSKIY, M.

[Text] Specialists of the Khar'kov Turbine Plant imeni Kirov and scientists have drawn up plans for nuclear power-and-heat generating turbines with capacities of 530,000 and a million kilowatts. These machines are intended for generating electric power and also for supplying steam and hot water to heating systems. The first units of this type will be sent to the Minsk Nuclear Heating and Power Plant, which is under construction. These units' efficiency rating is substantially higher than that of earlier models, and they will weigh one-third less.

"In designing the new turbines, we tried to make fuller use of the experience of Leningrad and Sverdlovsk specialists," said Candidate of Technical Sciences Yu. F. Kosyak, chief designer of the plant. "Technological solutions for the production of steam power-and-heat generating machines were developed by these specialists for the first time in Soviet practice. Mathematical simulation models which were calculated jointly with associates of the Ukrainian Academy of Sciences' Institute of Machine Building Problems were broadly utilized in the designing of these machines."

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UDC 621.311.8

FEASIBILITY OF USING AIRCRAFT GAS-TURBINE ENGINES AS STANDBY AT BUSBARS IN
NUCLEAR POWER PLANTS FOR RELIABILITY ASSURANCE

Minsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ENERGETIKA in Russian No 2,
Feb 85 (manuscript received 18 Jul 83) pp 81-83

SEULIN, N.A., candidate of technical sciences, Krasnoyarsk Polytechnic
Institute

[Abstract] An aircraft gas-turbine engine can be used as a reliable standby in a nuclear power plant, if it can start up from the cold state within 15 s and then be coupled to an electric generator running at a different speed. The normal startup time of an aircraft gas-turbine engine is 100-150 s. It is possible to reduce the acceleration period to 50-60 s by increasing the starter power, but a further reduction requires modification of the torque transmitting device, so that eventually a 1000 kW starter will accelerate typically an NK-4 engine within 5 s to full speed at a low gas level, for subsequent heatup within 10 s. Faster action requires an auxiliary starter turbine, one without a compressor which will rotate continuously with the synchronous electric generator at sufficient speed to ensure continuity of power supply. Matching turbine speed to generator speed requires coupling the two machines through a speed step-down or speed step-up transmission. The standby turbine, with a compressor or identical to the main turbine, can be mounted on the same shaft or on a separate one. The common-shaft configuration is structurally simpler but requires more cooling power. With all necessary measures implemented, it is feasible to install NK-4 6000 kW or AI-20 2500 kW gas-turbine engines as reliable standby in nuclear power plants at a cost of 70-95 rubles/kW. It appears furthermore feasible to extend the capacity of NK-4 engines to 16,000 kW for this standby application. Article was presented by Department of Electric Power Plants. Figures 2; references 3: 2 Russian, 1 Western. [169-2415]

QUANTITATIVE DETERMINATION OF TRITIUM FORMING IN COOLANT OF WATER-MODERATED WATER-COOLED POWER REACTOR

Moscow ATOMNAYA ENERGIYA in Russian Vol 58, No 1, Jan 85 (manuscript received 28 Dec 83) pp 57-59

POPOV, S.V., BABENKO, A.G., MEKHEDOV, B.N., ILYASOV, V.M., GOLUBCHIKOVA, I.G. and PODPORINOVA, L.Ye.

[Abstract] Even though the sources of tritium in a water-moderated water-cooled power reactor have already been established, it is still necessary to reconcile theoretical and experimental data. This requires a quantitative determination of tritium in the reactor coolant, where it forms. The tritium concentration and its rate of change during reactor operation, both being functions of time, are described by a first-order differential equation. The amount of tritium at the end of a reactor run is found by integration of this equation, assuming a constant water level in the primary loop and considering that the makeup water also contains tritium. Makeup water, added periodically, is usually pure condensate which not only compensates for coolant leakage but also keeps the concentration of boric acid at a constant level. The coolant is treated with boron concentrate, potassium hydroxide, ammonium, and hydrazine--all dissolved in pure condensate. These measurable factors are included in calculation of the tritium content at the end of a reactor run. Such measurements were made in a VVER-1000 MW reactor during an experiment extending over four runs, with lengthy shutdowns during the third run. The tritium concentration in the coolant and in the makeup water was found to increase with time, toward the peak of a parabola in the coolant and along a straight line in the makeup water, while the H_3BO_3 concentration decreased linearly. On this basis, the amount of tritium in the coolant was 2.7 ± 0.3 TBq after the third run and 4.3 ± 0.2 TBq after the fourth run. The authors thank V.V. Tagirov and V.N. Kuklin for helpful discussions. Figures 2; references 4: 3 Russian, 1 East German. [172-2415]

DC 621.039.515

CONTROLLABILITY RANGES FOR UNSTABLE NUCLEAR REACTOR

Moscow ATOMNAYA ENERGIYA in Russian Vol 58, No 1, Jan 85 (manuscript received 11 Mar 84) pp 3-7

POSTNIKOV, N.S.

[Abstract] A mathematical model is constructed for the stability and controllability analysis of nuclear reactors. Deviations of the neutron flux from its steady state are described by a system of three equations in the approximation of one-group diffusion, linearized in the vicinity of the steady

state. Assuming a generally multiply-connected regulation system for an unstable reactor, and a correspondingly weighted neutron multiplication factor, the space of variables in these equations is treated as the sum of two half-spaces. Each is an invariant manifold of the operator matrix, one stable and one unstable; the latter is assumed to be finite-dimensional. The problem of determining on this basis the region of ξ -controllability, within which initial perturbations and subsequent deviations of reactor parameters can be compensated, reduces to construction of a bounded convex space completely defined by its hyperplanes. In practice it is not always necessary to determine the controllability ranges of reactor parameters precisely; rather it is often sufficient to estimate them relative to upper bounds. For illustration, this method of analysis and calculations is applied to a reactor with one-dimensional neutron flow and with slow positive feedback, with a closed control loop in addition to a closed regulation loop. The reactivity u as function of the reactor space coordinate and of time t is expressed in the form

of a series $u(\xi, t) = \sum_{i=1}^{\infty} x_i(t) \sin \pi i \xi$, where $y_i = \int_0^1 u(\xi, t) \sin \pi i \xi d\xi = \frac{1}{2} x_i$.

Regulating rods will not stabilize the reactor in any one space harmonic when located at node points of this harmonic but will be effective when located at its crest points. The solution is relatively simple when the reactor is unstable in the fundamental harmonic only. When it is unstable in both the fundamental and the second harmonics, then their coupling must be taken into account and a singly-connected regulation system can stabilize the reactor in both. The controllability range of one regulating rod does not differ appreciably from that of two rods of equal total strength. The boundaries of the controllability region depend on the location of a regulating rod and in the case of reactivity $u(\xi) = x_2 \sin 2\pi \xi$ (fundamental harmonic only) deviations with amplitudes $|x_2| < 2 \Delta_2(\xi_1^*)$ (Δ_1 - effect of regulation on i -th harmonic, in this case second harmonic) can be compensated by a control rod at location ξ_1^* . Figures 2; references 11: 10 Russian, 1 Western (in Russian translation). [172-3415]

UDC 621.311.25:621.039.001

TRANSIENT PROCESSES IN POWER UNIT WITH VVER-440 MW WATER-MODERATED WATER-COOLED POWER REACTOR DURING OPERATION WITH POWER EFFECT AND WITH TEMPERATURE EFFECT

Moscow ELEKTRICHESKIYE STANTSII in Russian No 12, Dec 84 pp 15-17

ANDRUSHECHKO, S.A., engineer, and ZVERKOV, V.V., engineer, Kola AES

[Abstract] Transient processes in a power unit with a VVER-440 MW water-moderated water-cooled reactor were analyzed in two experiments at the Kola AES. The purpose was to establish the optimum rate of load shedding to a certain final level toward the end of the fuel cycle, with the reactor operating either in the power-effect mode or in the temperature-effect mode

of reactivity, without pulling the reactor into the "iodine" well. Reactor poisoning continued for 2 h after power reduction to the controllable level, with the Xe-135 concentration increasing appreciably in experiment 1 and negligibly in experiment 2, so that in the latter case the negative reactivity was lower and the uncontrollable power drop was smaller. The results reveal how the transient characteristics depend on the parameters of the primary loop and the parameters of the secondary loop. They also reveal a direct proportionality between the rate of pressure rise in the main steam collector and the rate of power drop, with the control valve to one turbo-generator fully closed. Figures 2; references: 1 Russian.
[176-2415]

UDC (621.311.25:621.039):621.65.004

EXPERIENCE WITH IMPACT END SEALS IN HIGH-SPEED PUMPS IN NUCLEAR POWER PLANTS

Moscow ELEKTRICHESKIYE STANTSII in Russian No 12, Dec 84 pp 17-18

MOSKALENKO, V.V., engineer, LISITSYN, K.V., candidate of technical sciences, and KUSTOV, V.P., engineer, All-Union Scientific Research Institute of Atomic Power Pumps and Novovoronezh AES

[Abstract] Impact end seals reduce leakage to the levels needed for contactless operation, which simple and reliable slit end seals cannot do. Therefore, impact end seals were installed in TsN 60-180 high-speed pumps operating in the primary loops of power units with VVER-1000 MW water-moderated water-cooled power reactors. Such a pump delivers 25 m³/h of borated water distillate at 70°C at a nominal speed of 8900 rpm, operating for 3000 h between scheduled shutdowns, with seals mounted on a shaft 70 mm in diameter and required to withstand a pressure of 0.6 MPa. The impact end seal has a modular structure, its stationary part and rotating part joined through a bracket, with external cooling. A total of 25,000 seal hours have been accumulated in two years of testing at 9000 rpm at 60°C, with the pressure drop varying over the 0.1-1.0 MPa range. The leakage rate was found to increase from 0.2 to 2.5 dm³/h within 7700 hours, principally owing to wear of the rubber O-ring in the axially movable seat. Design correction and adjustments restored these seals to their normal performance level. Figures 3; references: 5 Russian.
[176-2415]

SYSTEM FOR AUTOMATIC INSPECTION OF AIR STREAMS IN HERMETICALLY SEALED
ENCLOSURES OF PRIMARY LOOP IN NUCLEAR POWER PLANTS

Moscow ENERGETIK in Russian No 1, Jan 85 pp 11-12

BERSENEV, V.L., engineer, BAGAUTDINOV, Z.S., engineer, and PANOV, S.Yu.,
engineer, Ural Regional Engineering Administration of Power System Management

[Abstract] A special velocity transducer using a strain gauge has been developed for automatic inspection of the air flow in the primary loop of the Belogorsk AES. This transducer combines sufficiently high accuracy and reliability with simplicity of construction and operation under extra severe conditions in a nuclear power plant. The principle of this transducer is based on the change in the electrical resistivity of a metal or semiconductor which occurs upon a change in its state of stress and strain. The device consists essentially of a sensing element, a thin disk placed in a fairing channel, and an elastic element which is a beam rigidly joined to that disk. Two tensoresistor strips are bonded to the beam lengthwise on opposite sides and connected through a switch to an ohmmeter bridge. Displacement of the disk facing the air stream causes deflection of the beam and thus a change in the electrical resistance of the strips, this change being proportional to the air velocity. The disk is made of micarta, 0.5 mm thick and 30 mm in diameter. The beam is made of stainless steel, 35 mm long and $7 \times 0.09 \text{ mm}^2$ in cross-section. The tensoresistor base is 5 mm, and the distance from its center to the center of the disk is 19 mm. Both KF5P1 strips have a nominal resistance of 400 ohms. The purpose of using high-resistance tensoresistor strips and a cylindrical fairing channel is to ensure a large transducer output signal. The latter is further boosted by operating the transducer above its nominal rating, which can be done by connecting it to the bridge circuit intermittently rather than continuously. The transducer has been calibrated and tested in this mode of operation with an automatic BMS bridge circuit with commutator switch and amplifier. Its error does not exceed $\pm 3\%$, even in the low-velocity range. Figures 2.

[192-2415]

UDC 621.882.3.084:621.039.5

ELECTRICAL EQUIPMENT OF WRENCH FOR TIGHTENING MAIN BOLT-AND-NUT FASTENER ON
REACTOR VESSEL

Moscow ENERGOMASHINOSTROYENIYE in Russian No 2, Feb 85 pp 43-45

ANIKEYEV, F.D., engineer, BAZHENOV, V.P., engineer, NIKOLAYEV, V.P., candidate
of technical sciences, and RAZBITSKOV, V.I., engineer

[Abstract] The main fastener for locking the vessel of a VVER-440 MW or VVER-1000 MW water-modulated water-cooled power reactor is tightened by pulling 54 bolt pins (170 mm in diameter) 2.3 mm out and then turning the nuts on them, six at a time, in proper sequence. The wrench for turning these nuts consists

of a support collar, a rotating frame, and six hydraulic jacks mounted on that frame for pulling the bolt pins. The jacks operate with a pressure of 33 MPa in their cylinders. Both bolt pin pulling and jack frame rotation for sequential turning of the nuts are controlled either manually or automatically. The frame is driven by a 2-speed induction motor, high speed for rough positioning in minimum time and low speed for fine alignment of the jacks. The jack pump is driven by another induction motor, controlled by a selsyn for coordination with the jack frame. Auxiliary electrical equipment includes a main reversing and 10-position switch with 10 contactless pilot switches, a set of start switches, a dynamic brake with rheostat control for the jack frame motor, a set of disconnect switches, relays with resistive voltage divider, charge-discharge capacitor, and protective diodes, two rectifier bridges and two indicator light panels, one with a single lamp and one with six lamps, for d.c. control of and monitoring the wrench rotation, one rectifier bridge and one indicator light panel with two lamps for d.c. control of and monitoring the jack frame rotation, two 220/48 V stepdown transformers and two 220/24 V stepdown transformers in the wrench rotation circuit for supplying power separately to each rectifier bridge and a corresponding indicator light panel. All circuits and equipment have been designed for high-speed response and maximum reliability in a reactor environment, with the possibility of full automation. Figures 4; references: 2 Russian.
[193-2415]

UDC 621.165.62-5

FUNCTIONS OF TURBINE REGULATION SYSTEM IN NUCLEAR POWER PLANT

Moscow TEPLOENERGETIKA in Russian No 12, Dec 84 pp 19-22

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[Abstract] Automatic regulation in atomic electric power plants with 500 MW and larger turbines pertains to turbine speed, steam inlet pressure, load power, and network frequency. Such turbines produced at the Kharkov Turbine Manufacturing Plant must operate compatibly with either water-moderated water-cooled power reactors or graphite-water channel reactors, which is ensured by a universal electrohydraulic regulation system. The five basic algorithms, each involving one integration and subsequent addition of up to two terms, with appropriate coefficients and their specified ranges of values, cover respectively speed regulation, turbine speed and reactor pressure regulation, power regulation, steam pressure regulation, steam pressure and turbine power regulation. The principal function of this regulation system is limiting the power within upper and lower bounds determined by the constraints on load buildup and load shedding requirements as well as by changes in the turbine operating conditions. Other functions include control

of turbine performance under load when the performance does not depend on other plant components, idling the turbine without runaway after load shedding, pull-up and synchronization, and intentional speed increase for inspection of automatic protective relaying system. The main problem is establishing the optimum hierarchy of mode switching, which requires an analysis of transients plant-wide in addition to matching the turbine characteristics. Tables 3; references 2: 1 Russian, 1 Western.
[174-2415]

UDC 621.187.139:621.67

INDUSTRIAL TESTS OF PT 3750-100 FEEDWATER TURBINE-PUMP SET IN 1000 MW POWER UNIT WITH VVER-1000 WATER-MODERATED WATER-COOLED REACTOR

Moscow TEPLOENERGETIKA in Russian No 12, Dec 84 pp 22-25

KIRSH, A.K., engineer, SHISHKIN, A.G., engineer, PANFEROV, A.I., engineer, and MARTYNENKO, A.F., engineer, Planning Department, State All-Union Engineering Administration of Power Systems; Novovoronezh AES

[Abstract] The feedwater turbine-pump set serving two K-500-60/1500 turbines in power unit No 5 of the Novovoronezh AES with VVER-1000 MW water-moderated water-cooled reactor was subjected to an industrial test, for the purpose of design and performance evaluation. The set consists of a PT 3750-75 main feedwater pump, a PT 3750-200 pilot pump, and an OK-12A condenser-type turbine with a speed reducer for driving the pilot pump. The main pump is a 3-stage centrifugal unit of horizontal double-casing design, with a sectionalized inner casing and a discharge drum. It is mounted on two journal bearings and one thrust bearing with forced-feed lubrication and with slit end seals locked by cold condensate. Its rating is: capacity 3760 m³/h, head 7.16 MPa, speed 3500 rpm, power 9250 kW. The pilot pump is a single-stage centrifugal unit of horizontal design with a double-inlet impeller, also mounted on two journal bearings and one thrust bearing with slit end seals locked by cold condensate. Its rating is: capacity 3650 m³/h, head 1.78 MPa with 0.085 MPa margin for cavitation, speed 1800 rpm, power 2460 kW. The turbine is a 10-stage single-cylinder unit with throttle-type double-valve steam distribution. It operates with 248°C - 0.99 MPa steam against 6 kPa backpressure, the nominal steam rate being 69.5 t/h and the speed range 3500-2645 rpm. The object of testing was to determine the thermodynamic characteristics of the steam, then the internal efficiency of the set as function of the steam rate from light load to full load, the pressure-flow characteristics, and the power-speed characteristics. The measured efficiency, an average of eight readings, was 82.9% over the entire range of steam rates and thus very close to the calculated 82.5%. Figures 3.
[174-2415]

COMPARING TURBINES WITH STEAM SEPARATOR-SUPERHEATER OR WITH TWO MOISTURE EXTRACTIONS FOR NUCLEAR POWER PLANTS

Moscow TEPLOENERGETIKA in Russian No 12, Dec 84 pp 26-30

KOSTYUK, A.G., doctor of technical sciences, POVAROV, O.A., doctor of technical sciences, and DERKACH, A.I., engineer

[Abstract] After the detrimental effect of steam wetness on the economy of turbine operation in nuclear power plants was established, two methods of increasing the steam quality are evaluated comparatively for two turbines. The conventional method, by means of an external separator-superheater and 2-stage intraturbine moisture extraction, are tentatively applied to two versions of the K-1030-60/1500-1 turbine built at the Kharokov Turbine Manufacturing Plant, each with a separate medium-pressure cylinder between the high-pressure cylinder and three low-pressure cylinders instead of the second high-pressure cylinder. One version has two superheating stages, a set of three high-pressure superheaters and a set of four low-pressure superheaters. The proposed second version has two moisture extraction stages. The comparison criteria are total losses, which determine efficiency, and reliability. These performance parameters were evaluated on the basis of pressure and power levels at eight successive bleeder points in the five cylinders, according to conventional thermodynamic relations and available reference data. For comparison, the initial steam quality and pressure as well as feedwater temperature and final steam pressure are assumed to be the same in each case. The results indicate that conclusions as to the choice of scheme depend on the method of estimating the losses associated with wetness of steam. Precise accounting of these losses yields a slightly higher turbine efficiency for 2-stage intraturbine moisture extraction. Other factors such as reduced corrosion and easier maintenance also favor this scheme over external steam separation-superheating. Figures 4; tables 2; references: 7 Russian.

[174-2415]

USE OF SECTIONAL-MONOLITHIC BLOCKS IN CONSTRUCTION OF SECOND-GENERATION CHERNOBYL NUCLEAR POWER PLANT

Moscow ENERGETICHESKOYE STROITELSTVO in Russian No 11, Nov 84 pp 6-8

TSENENKO, I.K., engineer, and ALEKSANDROV, N.Ye., engineer

[Abstract] A cost analysis made at the All-Union Design, Surveying and Scientific Research Institute of Hydro Projects has revealed that erection of about 0.9 m thick reinforced-concrete walls in sectional-monolithic blocks is much more economical, in terms of both labor intensity and metal content, than by either all-sectional or all-monolithic construction. This technique is

therefore used in building the second-generation third power unit in the Chernobyl AES with an RBMK-1000 MW graphite-water channel reactor. Pairs of concrete slabs joined by rows of steel rods so as to form double-panels are assembled into blocks, and the latter are built up into complete wall structures, with the panels joined by slats across splits on both the inside and the outside. A special semitrailer with 30 t capacity is used to transport the panels and blocks with a KamAZ-5410 or KrAZ-258 truck, and a KP-640 gantry crane with hooks on a special suspension beam is used for positioning them in final assembly. As a result, labor has been reduced from 4.85 man·days/kW in the first power unit to 1.92 man·days/kW in this third power unit, and the steel content has been reduced from 9.5 to 5.5 kg/m³. The also very low figure of average 1.41 man·days/m³, actually only 0.84 man·days/m³, is attributable to the fact that 102,400 m³ of wall structure are being installed here, versus 44,000 m³ having been installed in the first power unit. Furthermore, the installation time is 33 months shorter and the total labor cost is 41% lower. Figures 3; tables 2.
[175-2415]

UDC 621.311.25:621.039:693.546.2.658.5

ORGANIZATION OF CONCRETE WORK IN CONSTRUCTION OF CHERNOBYL NUCLEAR POWER PLANT

Moscow ENERGETICHESKOYE STROITELSTVO in Russian No 11, Nov 84 pp 8-9

LYSYUK, R.I., engineer, and KAREVA, A.P., engineer

[Abstract] Experience in constructing the fourth power unit in the Chernobyl AES, with an RBMK-1000 MW graphite-water channel reactor, indicates how installation of monolithic concrete structures can be made more efficient and economical. It is necessary to increase the number of concrete laying machines and increase the daily quota of concrete laying to 1000-1200 m³, to develop and introduce automatic control of concrete delivery to construction sites, to automatically control the concrete mixing and curing processes, to add more concrete mix to the biological shield and to economize on the volume of monolithic concrete in the power units. Two special grades of heavy dry concrete are used for construction in the Chernobyl AES: one without metal filler having a density of 3.3-3.5 t/m³ after 28 days and one with metal filler, in the most suitable combination of iron-ore gravel or pebbles and cast-iron shot added to sand or cinder, having a density of 4 t/m³ minimum after 28 days. The total 1100 m³ of concrete structure laid in each power unit contains 700 m³ of the first grade and 400 m³ of the second one. The concrete is mixed with special vibrators on flexible shafts and is transported in special drums on trucks. During subzero weather the concrete is laid under makeshift tents with the air inside heated to +5°C, using forms and reinforcement preheated to at least 3°C. The concrete can withstand temperatures within the 200-350°C range and 50-200 frost-thaw cycles, its water permeability is within the 0.2-0.8 MPa range. Tables 1.
[175-2415]

SCHEME FOR MECHANIZATION OF CONSTRUCTION WORK IN MAIN HOUSING OF SECOND-GENERATION CHERNOBYL NUCLEAR POWER PLANT

Moscow ENERGETICHESKOYE STROITELSTVO in Russian No 11, Nov 84 pp 10-12

GRITSENKO, A.S., engineer, and ZAVGORODNIY, I.M., engineer

[Abstract] A scheme has been developed at the All-Union Design, Surveying and Scientific Research Institute of Nuclear Power System Construction for mechanizing the installation of equipment in the main building of the second-generation Chernobyl AES. The preparatory operations include digging the foundation pit under the main building and under circulation water piping, placement of the foundation plate under the main building, erection of support walls and transportation scaffolding, laying access paths and supply lines, and installation of circulation water piping. The subsequent three principal operations are installation of all necessary cranes in the reactor compartment, prevention of "chasms" of equipment incompleteness found to have developed in previously built nuclear power plants with RBMK-1000 MW graphite-water channel reactors, and maximum buildup of structures into blocks delivered to assembly areas by railroad or truck. A variety of cranes is used throughout the installation work, their number and type appropriate for each particular operation. Figures 1.
[175-2415]

NON-NUCLEAR ENERGY

PROGRESS REPORT ON CRIMEAN SOLAR POWER STATION

Moscow IZVESTIYA, 1 May 85, p 2

[Excerpt] Like seats in a circus, mirror heliostats surround the tower of a steam generator. On the eve of May 1, the intense beams of sunlight reflected by them were collected on the black surface of the cap of the 90-meter tower. The temperature inside the solar boiler began to rise rapidly. This was one of the first tests of the performance of the main systems of the Crimean Solar Power Station (SES-5), as reported from the town of Shchelkino in the Crimean Oblast by correspondents A. Blokhnin and S. Troyan.

The first pilot-plant solar power station, which is being built in the Crimea and which is called a 'tower-type thermodynamic power station,' will generate current this summer.

In comparison with existing power giants, its capacity is small--5,000 kilowatts in all.

The heliostat mirrors cover an area of 4 hectares. To install the supports under the panels for capturing the sunlight, 34 kilometers of piles were driven. We give these figures in order to show that the installation of a solar power station is far from a simple matter. Let us add further that a computer will control the solar tracking systems at each one of the 1,600 heliostats. It has already been installed, and adjusters are now at work in the room of the computer center.

"Our main task during the first stage of the solar power station's operation," said O. Dmiterko, director of the station, "is to check the reliability of the equipment and its efficiency. The next step will be to increase the solar power station's capacity to 15,000-20,000 kilowatts. Engineers have already begun work on the reconstruction project. Still ahead are experiments with an industrial heat-storage system. This means that the station will not cease to operate right after sunset. At SES-5, promising designs of heliostats (in particular, of the focusing type) and new units of a microprocessor-based automated tracking system will be tested.

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ELECTRODEPOSITION INCREASES SOLAR HEAT PANEL EFFICIENCY

Moscow MOSKOVSKAYA PRAVDA, 12 May 85 p 1

AVETISOVA, I.

[Excerpt] Specialists of the USSR Academy of Sciences' Institute of High Temperatures (IVTAN) and the Moscow Evening Metallurgy Institute (MVMI) have developed a process for making high-efficiency coatings for solar panels which permits more effective use of solar power in the economy.

At the galvanic-coatings training shop of the Moscow Chemical Engineering Trade School (MKhTT), preparations for the main operation were completed, and several minutes later a solar panel was immersed in a chrome-plating bath. After a while, the finished panel shone with a dull black-violet coating. Thanks to this coating, it is possible to store the energy of the sun and make it 'work.'

Scientists have proved that a thin layer of black coating suffices to absorb the sun's energy. And, the thinner the coating, the less it is subject to thermal destruction and the less stored heat it allows to escape. If this layer is applied to a metal with good [thermal] conductivity, the heated panel will release almost no heat to the environment.

But how can such a thin layer of coating be produced? It must be no thicker than three-tenths of a micron. Such a layer can't be applied with a brush or an atomizer. Scientists of IVTAN and MVMI undertook to solve this problem.

The proposed process is based on the electrodeposition principle. With it, a more efficient conversion of solar power into heat was achieved. According to calculations of specialists, the proposed process results in 20-40 percent higher efficiency of panels having such a coating, and their service life is 10 instead of 2-3 years. At the same time, the temperature of the heat-transfer agent can be increased to 200 degrees.

Before the new process can be put to industrial use, it must be carefully perfected and tests must be made on panels of standard industrial size. This problem has been solved by the leaders of the project--A. V. Mareichev, a docent in MVMI's chair of corrosion, and M. D. Friedberg, a science associate of IVTAN's department of novel power engineering units, which is based at MKhTT.

The new process will soon be widely used in industry.

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GENERATOR USES TEMPERATURE DIFFERENCE OF ARCTIC AIR AND SEA WATER

Moscow STROITEL'NAYA GAZETA, 26 Apr 85, p 3

[Text] "Sovetskaya Arktika" is the name of an electrical unit--a 'mini-power station'--which has been developed at the Pacific Oceanology Institute for areas of the Far North. The potential of the difference between the temperature of sea water under ice in the wintertime and that of the freezing surface air is converted into electric power by this unit.

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CSO: 1861/258

TECHNICAL-ECONOMIC FEASIBILITY OF ORBITING SUNLIGHT REFLECTORS

Moscow NTR: PROBLEMY I RESHENIYA, 19 Feb 85, p 6

ALFEROV, Zh., academician; KANTOR, V., Candidate of Technical Sciences
MININ, V., senior science associate

[Abstract] The article discusses the idea of placing reflectors in orbit as a means of providing artificial illumination, which is said to be 'entirely feasible.' Considerations of technical and mainly economic feasibility of the idea are addressed.

Three main areas of application of such a scheme are distinguished: reflecting sunlight onto the Earth's surface; concentration of the flow of solar energy on an orbiting receiver; and retransmission of optical radiation. The first application aims at nighttime illumination of cities and of farmland. It is said this could be accomplished for practically any geographic latitude. Details of one such hypothetical scheme are presented. It involves a reflector with a reflecting surface of 110 square meters in an orbital period of 1.5 hours. A drawing of the Earth and the reflector's orbit, with the illuminated region of the planet's dark side, is given. Data on the time of ascent of the reflector above the horizon and its illumination power in terms of full-moon equivalents are cited. It is said that this scheme would employ a whole 'caravan' of such reflectors passing in sequence over the illuminated region. Also given is a drawing with top and side views of an orbiting reflector that is currently being developed at the Moscow Aviation Institute.

The second promising application mentioned is concentration of the flow of sunlight on some receiver in orbit, such as the solar panels of an orbiting station. It is said that because the size of the reflector for this purpose would not have to be more than several dozen meters, this application could be realized earlier than the others. This idea is said to be particularly attractive in view of estimates that within the next 10 years, the power requirement of long-term orbiting stations will reach hundreds of kilowatts.

Finally, it is said that broad possibilities exist for orbiting reflectors as retransmission systems for organizing global communications using lasers. Such communications channels would possess extremely high throughput capacity and noise immunity.

The article goes on to discuss advantages of the artificial Earth-illumination application of the orbiting reflector scheme in terms of energy savings in lighting cities, and additional daylight time for critical periods of farming operations.

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UDC 621.375.4

HIGH-SPEED HIGH-VOLTAGE AMPLIFIER

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 84 (manuscript received 27 Jan 84) pp 237-238

DYACHKO, A.N., ILYUSHENKO, V.N. and TUYEV, V.I., Chair of Radio Receivers and Amplifiers, Tomsk Institute of Automatic Control Systems and Radioelectronics

[Abstract] A high-speed amplifier of high-voltage pulse signals coming from remote sources over long transmission lines is now available, specifically designed for increasing the sensitivity of 6 LOR-04 oscillographs. It includes a line attenuation compensator, besides the amplifier stage with a main output and an output for oscillograph synchronization. Each component can be used independently for any particular other application. The amplifier delivers negative voltage pulses of 300 V or higher amplitude and 200 ns duration at a repetition rate of 10 kHz or higher to a 75-ohm load, with rise and fall times not exceeding 3 ns and with the pulse top flat within 10%. Its gain is 66 dB with manual regulation over a 40 dB range, its dynamic range is 40 dB at the input, and its amplitude characteristic is linear within 15% over the 30-300 V range. The amplifier stage uses a 60 V power supply and draws 0.9 A, the attenuation compensator uses a 15 V power supply and draws 0.15 A. The sizes of the two modules are 280x190x60 mm³ (weight 3 kg) and 90x45x30 mm³ (weight 0.3 kg), respectively. Figures 1.
[107-2415]

UDC 621.316

MULTICHANNEL RING COMMUTATOR FOR HIGH-CURRENT ACCELERATORS

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 84 (manuscript received 11 Apr 85) pp 21-23

ISAKOV, I.F., LOGACHEV, Ye.I. and REMNEV, G.Ye.

[Abstract] A ring commutator with parallel channels in a common gas chamber and with a switching capability of 0.4 MA under 1 MV has been developed for

high-current accelerators. The feasibility of such a commutator was established in an experimental study of dischargers and their triggering by distortion of the electric field. The necessary distortion is achieved by inserting the auxiliary electrode asymmetrically from the side and grounding it through the discharger and a current-limiting resistor. The study also revealed that mutual brightening illumination of parallel dischargers improves the stability of their triggering; a 30-40% smaller variance of the delay time is quite feasible. The commutator has an inductance of 40 nH, and its working medium is an "elegas"+nitrogen mixture in a 1:10 ratio under a 0.5 MPa pressure. It was tested in the TO-NUS-1 accelerator, where switching through a twin shaping line did not delay the triggering by more than 22 ns at a 0.9 ratio of control breakdown voltage to self-sustained breakdown voltage. Figures 4; references 5: 4 Russian, 1 Western (in Russian translation). [107-2415]

UDC 621.373.44

HIGH-CURRENT ELECTRON ACCELERATOR

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 84
(manuscript received 16 May 83) pp 19-21

ALEKSEYEV, B.V., GORELIKOV, I.M., KAZUROV, V.I., MASHKOV, L.V., ORESHKO, A.G., SOKLAKOV, G.I., FEDORENKO, A.I. and YURKEVICH, K.B., Moscow Institute of Aviation

[Abstract] A high-current electron accelerator has been developed and built on the basis of computer-aided design calculations and electrolytic-trough simulation. A 15-stage Arkadyev-Marx pulse voltage generator serves as the primary energy storing device, each stage consisting of two IK-100-0.4 capacitors connected in parallel and all immersed in transformer oil inside a metal container on electrically insulating posts. Each stage is shielded on both the positive potential and negative potential sides. The shields, made of copper foil, not only smooth the electric field in the clearances but also constitute parts of the commutating circuit and thus contribute to reduction of the overall generator size. The dischargers, all inside a common cylindrical chamber with walls made of acrylic glass and with an atmosphere of nitrogen under a pressure of 1 atm, are irradiated with ultraviolet light during switching to stabilize the generator triggering with minimum variance. The pulse voltage generator is triggered by a synchronizer through the conventional firing circuit of a TG11-350/16 thyatron. To operate the accelerator in the nanosecond mode, the generator discharges into a diode through a twin shaping line. In this mode the accelerator can produce 0.8 MeV - 240 kA electron beams of 0.8 ns duration. To operate the accelerator in the microsecond mode, the shaping line acts as storing capacitor, and the discharge gaps in its commutator must be short-circuited by busbars while the pulse generator must be charged with polarity reversal in each stage. In this mode the accelerator can produce 0.5 MeV - 10 kA electron beams of 1 μ s duration. Figures 2; references: 3 Russian. [107-2415]

SELECTION AND JUSTIFICATION OF SYSTEM PARAMETERS FOR PUMPED-STORAGE ELECTRIC POWER PLANTS IN DYNAMICS OF POWER SYSTEM DEVELOPMENT

Moscow GIDROTEKHNICHESKOYE STROITELSTVO in Russian No 12, Dec 84 pp 4-7

SHARYGIN, V.S., candidate of technical sciences

[Abstract] An evaluation procedure is presented for economically justifying a pumped-storage electric power plant in preference to other alternatives such as an adjustable thermal electric power plant for partial peak coverage, a gas-turbine electric power plant, or a nuclear power plant. The cost indicators are based on selection of optimum plant parameters, which in the hydro-electric case depend largely on power underutilization and largely influence the depreciation rate. The cost indicators are obtained for several possible structural variants, considering each power level in a daily operating cycle as well as the hours of operation at each level. Next are considered projections of power and energy demand for the 1990-2000 period, for calculating the daily variation of cost effectiveness as well as the cost effectiveness as a function of installed capacity and of daily available energy. Finally are considered changes in the optimum values of parameters depending on the projected installation schedule. The procedure is demonstrated using the specific case of a pumped-storage electric power plant under consideration for the Northern-Western power grid, to be installed in two stages over the 1991-1995 and 1996-2005 periods, respectively. Figures 7. [170-2415]

PLASMATIC ION SOURCE

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 84 (manuscript received 9 Mar 83) pp 23-24

SEMENOV, A.P., Institute of Natural Sciences, Siberian Department, USSR Academy of Sciences, Buryat branch, Ulan-Ude

[Abstract] A plasmatic ion source has been built in which the hollow cathode above two discharge-chamber cathodes is readily replaced upon depletion after 250-300 h and the emission outlet hole is restored to original size by replacement of the cathode insert, while gas is continuously admitted by means of a spring mechanism. The source operates in the Penning discharge mode, with argon as the working gas. The hollow cathode is 36 mm long and has an inside diameter of 4 mm. The other two cathodes serve as pole shoes of a toroidal ferrite magnet which produces a longitudinal magnetic field of 0.1 T induction in the discharge chamber. All three cathodes are made of magnetic steel and are insulated from the cylindrical copper anode by teflon spacers. Heat is dissipated by oil, which carries it away to a water-cooled

housing compartment. The source generates an ion emission current of 20 mA with a discharge current of 200 mA at a pull voltage of 20 kV. Figures 4; references: 2 Russian.
[107-2415]

UDC 621.226.3

DESIGN OF PNEUMOHYDRAULIC ACCUMULATORS WITH HIGH-COMPRESSIBILITY ENERGY STORING MEDIUM

Minsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ENERGETIKA in Russian No 11, Nov 84 (manuscript received 18 Jul 83) pp 95-97

TELITSA, S.G., candidate of technical sciences, LAPTEV, Yu.N., professor, and VINOGRADOV, L.M., docent, Volgograd Polytechnic Institute

[Abstract] A pneumohydraulic accumulator for a hydraulic drive must be designed so as to ensure that the volume of fluid satisfies the requirements of such a drive without being excessively large. The main requirement is that during discharge of the fluid from the accumulator tank its pressure do not drop below the drive operating level. The design of such accumulators is usually based on the equation of the polytropic process. Since no data on the thermodynamics of compression and expansion processes involving high-compatibility energy storing media are available, with mixtures of carbon dioxide and nitrogen being now considered in preference to nitrogen alone, a preliminary estimate of their thermodynamic indicators is necessary before the optimum mixture for maximum useful work and fastest response as well as maximum economy of metal in the tank structure can be determined. Accordingly, the accumulator work cycle is treated as a 2-stage cycle of isothermal charge and polytropic discharge. The calculations are based on pressure-volume diagrams of both processes, for determining the volume of fluid delivered and the work done by the accumulator. Numerical data based on these relations and typical operating conditions were obtained for optimum mixtures corresponding to various durations of the discharge process, and found to agree closely with experimental data, yielding almost the same value for the polytropic exponent in each case. A similar theoretical and experimental evaluation with fairly consistent results has also been made for the isothermal charge process. Article was presented by Department of Hydraulics and Hydraulic Drives. Figures 2; references: 2 Russian.
[166-2415]

DEPENDENCE OF PARAMETERS OF SILICON-TYPE PHOTOELECTRIC CONVERTERS ON TEMPERATURE AND LIGHT INTENSITY

Tashkent GELIOTEKHNICA in Russian No 6, Nov-Dec 84 (manuscript received 6 Jul 84) pp 3-8

BORISOV, S.N., GORODETSKIY, S.M., GRIGORYEVA, G.M., ZVYAGINA, K.N. and KASYMAKHUNOVA, A.M., "Order of Labor's Red Banner" All-Union Scientific Research Institute of Current Sources

[Abstract] The performance of silicon-type photoelectric converters with 1 ohm·cm nominal electrical resistivity of the material were measured at +20°C, using a variable-intensity solar radiation simulator as a light source and keeping the device temperature constant. The data yielded current-voltage curves for various levels of the photocurrent; the total current is equal to the sum of the photocurrent and diode current, also the dependence of current and voltage as well as efficiency on the density of incident radiation power. The current-voltage curves were found to flatten out with increasing light intensity. The results are used for an evaluation of the equivalent-circuit series resistance and its leakage component. The former is calculated from the ideal current-voltage characteristics with correction for a real device. The latter is calculated on the basis of Ohm's law and current balance in a thin front layer, taking into account the presence of a substrate as well as of metal contact tabs on both front and back sides. The current dependence of the resistance thus established indicates that the series resistance consists almost solely of its leakage component under light loads, but becomes increasingly larger than this component under heavier loads. Figures 4; references 5: 3 Russian, 2 Western. [167-2415]

CHARACTERISTICS OF SOLAR CELLS WITH SCHOTTKY BARRIER AND CURRENTS THROUGH SURFACE STATES

Tashkent GELIOTEKHNICA in Russian No 6, Nov-Dec 84 (manuscript received 13 Jun 83) pp 8-13

ZINETS, O.S., KILCHITSKAYA, S.S. and STRIKHA, V.I., "Order of Lenin" Kiev State University imeni T.G. Shevchenko

[Abstract] The characteristics of solar cells with a Schottky barrier are calculated, taking into account the thin interlayer between metal and semiconductor as well as electron surface states at the semiconductor-interlayer interface. The analysis is based on the diode theory of rectification with charge carriers flowing through the electron surface states, considering that these states can become generation-recombination centers, can provide

an additional channel for charge carriers between metal and semiconductor, and can cause a voltage redistribution in the metal-interlayer-semiconductor structure. Both electron and hole currents are treated as sums of a current flowing above the barrier and a current flowing through the electron surface states. All currents, including a diffusion current across the interface between the space-charge region and the quasi-neutral region, are evaluated as functions of the interlayer thickness for three modes of carrier exchange through the electron surface states: 1) between the metal and the semiconductor valence band; 2) between the metal and the semiconductor conduction band; 3) between the two semiconductor bands. Each exchange mode is characterized by respective pairs of kinetic exchange coefficients and involves the photocurrent generated in the space-charge region. The results indicate that electron surface states, when channeling photocurrent carriers into the metal, increase the efficiency of such a solar cell with a thicker than optimum interlayer. Figures 3; references 6: 2 Russian, 4 Western.
[167-2415]

UDC 621.362:621.383.5

UTILIZATION OF SOLAR ENERGY IN STEAM-TURBINE PLANTS

Tashkent GELIOTEKHNICA in Russian No 6, Nov-Dec 84 (manuscript received 8 Jun 83) pp 16-20

MERCHANSKIY, V.D. and ORLOV, A.Yu., Leningrad

[Abstract] Several schemes are considered for utilizing "free" solar energy in heat and electric power generating plants, specifically steam-turbine plants, as means of economizing on fossil fuel. The simplest scheme involves a solar heat collector with an evaporator from which steam under high pressure enters the turbine, where it expands adiabatically while delivering work and from where it proceeds to a low-pressure condenser. From here steam at constant temperature and pressure is pumped back into the solar heat collector. The drawbacks of this scheme are the strong dependence of the steam temperature on the intensity of solar radiation and thus on the time of day as well as on the weather, low quality of the working steam with its high liquid content, resulting in erosion and corrosion of turbine blades, and inefficient utilization of solar energy. These drawbacks are mitigated by use of a buffer medium for solar heat collection, whether water, mineral oil, or Freon with a boiling point higher than that of the working fluid. The buffer medium is pumped back from the steam generator to the solar heat collector after its heat has been transferred to the working steam, while the latter is pumped back from the condenser to the boiler. To smooth plant performance even more and at the same time increase its thermal efficiency, the solar heat collector is split into two compartments, with one connected into the steam generator loop and one operating as superheater for the working steam. While the performance of a plant according to this scheme still depends on the intensity of solar radiation, it is nevertheless enhanced by operating with dry steam in the turbine and with a lower pressure in the condenser. A comparative evaluation

of this scheme with parabolic cylindrical reflectors as solar heat collectors has been made for a 100 kW (electrical) turbogenerator, using ammonium, Freon-12, or Freon-22 as the working medium with 20 kgf/cm² initial pressure and 110-120°C initial temperature in each case. The steam rate is lowest (1427 kg/h) with ammonium, but the active surface of the solar heat collector and the unit cost are lowest (458.7 m², 0.66 rubles/W) with Freon-12. Figures 2; tables 1; references: 3 Russian. [167-2415]

UDC 621.362:621.383.5

EFFECT OF HIGH ILLUMINANCE LEVEL ON DIODE PARAMETERS 'A' AND 'I₀' OF PHOTO-ELECTRIC CONVERTERS WITH AlGaAs/GaAs HETEROSTRUCTURE

Tashkent GELIOTEKHNIKA in Russian No 6, Nov-Dec 84 (manuscript received 9 Feb 84) pp 20-22

MIRZABAYEV, M., RASULOV, K. and KOMILOV, A., Institute of Engineering Physics imeni S.V. Starodubtsev, UzSSR Academy of Sciences

[Abstract] A summary is given of available experimental data on the performance characteristics of photoelectric converters with p-Al_xGa_{1-x}As/p-GaAs/n-GaAs heterostructures on concentrated sunlight. As the illuminance level increases from 16,570 to 1,952,490 W/m², the current-voltage characteristic rises from flat to steep, with the short-circuit current increasing first linearly from 140 to 4050 mA/cm² at 400,000 W/m² and then hyperlinearly to 9000 mA/cm² at 1,952,490 W/m², while the open-circuit voltage changes only within the 0.98-1.02 V range. The diode parameters A, R_{ser}, I₀ in the relation

$$I_{sat} = I_{phot} - I_0 [e^{q(V_{sat} + IR_{ser})/AkT} - 1]$$

(I_{sat} - saturation current, I_{phot} - photocurrent, R_{ser} - series resistance, V_{sat} - saturation voltage, q - charge, T - absolute temperature, k - Boltzmann's constant) are given for the 610-589,820 W/m² range of illuminance, which corresponds to the 1-770 range of the concentration coefficient. The dependence of A and I₀ on illuminance is explained by the buildup of generation centers which act as deep traps in the p-n junction. The mechanism of current flow through the p-n junction in darkness and under light can also be explained. An increase of the illuminance level will obviously increase the concentration of excess minority carriers, as a result of double optical transitions, which in turn increases the probability of their entrapment by deep recombination centers and thus shorten their life-time so that both I₀ and A increase. Figures 1; tables 2; references 12: 9 Russian, 3 Western (1 in Russian translation). [167-2415]

LAYING OUT TOWER-TYPE SOLAR ELECTRIC POWER PLANTS

Tashkent GELIOTEKHNIKA in Russian No 6, Nov-Dec 84 (manuscript received 11 Jun 83) pp 23-26

TEPLYAKOV, D.I., APARISI, R.R. and GONCHARENKO, V.M., State Scientific Research Institute of Power Engineering imeni G.M. Krzhizhanovskiy

[Abstract] Design optimization of tower-type solar electric power plants must take into consideration the earth surface relief of the given territory and the geographical latitude of the proposed plant site. The optimum layout, namely tower position and orientation relative to the heliostat array, depends on the heliostat configuration and on the geometry of the solar heat collectors. Typical heliostat configurations are centrisymmetric, axisymmetric, or more intricate. Centrisymmetric configurations are preferable for pilot projects, inasmuch as changeover from any one to any other is most easily affected. A solar heat collector-concentrator can be open or closed (hollow), the simplest open ones being a plane horizontal one for a circular layout and a plane vertical or oblique one for a unilateral layout. There also conical and spherical ones of either open or closed type. A cylindrical vertical open one for unilateral irradiation is located centrally in the SES-5 experimental plant on the Crimean shore of the Azov Sea and eccentrically located in Barstow, California. Plane vertical ones or cylindrical oblique hollow ones are combined with a sectoral heliostat in Albuquerque, N.M., in West Germany (GAST), in Sicily (EURELIOS), in Spain (CESA), and an inverted cylindrical hollow one for irradiation from below with a centrally laid out heliostat array is installed in Ino, Japan (Shikoku island). Figures 1; references: 4 Russian. [167-2415]

UDC 662.997:537.22

ANALYTICAL CALCULATIONS FOR DESIGN OF PARABOLIC CYLINDRICAL CONCENTRATOR WITH CIRCULAR CYLINDRICAL COLLECTOR

Tashkent GELIOTEKHNIKA in Russian No 6, Nov-Dec 84 (manuscript received 12 Jun 83) pp 27-32

AVANESOV, E.S. and BAUM, I.V., Scientific-Industrial Association "Slontse", Ashkhabad

[Abstract] A parabolic cylindrical concentrator with a circular cylindrical collector is designed by an analytical method, assuming that the focus line of the concentrator coincides with the collector axis. The concentration of radiant flux by a parabolic cylindrical mirror and its subsequent reflection onto a circular cylindrical collector are analyzed on the basis of the photometric integral, namely the integral of the illuminance function over a given

solid angle. For evaluation of this integral, the space distribution of illuminance is parametrized with respect to two angles: one in the meridional plane and one in the perpendicular to its sagittal plane. This evaluation also requires the reflector precision factor as well as the reflection coefficient and the concentration factor characterizing, respectively, the physical properties and the geometry of the mirror surface. Allowance is made for the radius of the sun circle and the radius of the collector tube. Figures 4; references 3: 2 Russian, 1 Western.
[167-2415]

UDC 621.472

ERROR ANALYSIS OF LARGE SOLAR POWER PLANTS

Tashkent GELIOTEKNIKA in Russian No 6, Nov-Dec 84 (manuscript received 11 Jun 83) pp 32-37

AZIMOV, S.A., KULAKHMEDOV, N.N. and PIRMATOV, I.I., Institute of Engineering Physics imeni S.V. Starodubtsev, UzSSR Academy of Sciences

[Abstract] The errors of a large solar power plant are analyzed for the purpose of determining their effect on performance accuracy. Such a plant is treated as a solar furnace consisting of a multifaceted concentrator and a heliostat array. The four basic errors are flaws in the glass, the principal active material, deformation of mirrors and metal structures under wind, weight, and heat, manufacturing and alignment imprecision of the concentrator elements, inaccuracy of sun tracking by the heliostat elements as well as their alignment imprecision. Each of these errors is evaluated individually, and its statistical distribution is determined, whereupon the resultant error and its distribution are obtained. Addition of errors is a problem because it cannot be done in a straightforward manner. As an example, calculation of the combined effect of glass imperfection and tracking inaccuracy requires a geometrical analysis of the respective deviations and the use of pseudorandom numbers. The results of such an evaluation for the specific case of a paraboloidal concentrator and a plane heliostat, based on available data, indicates that the principal error lies in the local shape imperfections of optical glass with a Gaussian distribution and in the manufacturing imprecision of concentrator facets. The resultant error has a Poisson distribution. Figures 5; references: 10 Russian.
[167-2415]

CYLINDRICAL HEAT COLLECTOR FOR SOLAR-TO-THERMAL ENERGY CONVERTERS

Tashkent GELIOTEKHNIKA in Russian No 6, Nov-Dec 84 (manuscript received 10 Nov 83) pp 37-40

GAZIYEV, U.Kh., TRUKHOV, V.S. and FATTAKHOV, A.A., Institute of Engineering Physics imeni S.V. Starodubtsev, UzSSR Academy of Sciences

[Abstract] The radiative heat transfer in a solar heating plant with a cylindrical heat collector is analyzed, for purposes of design and performance analysis, taking into consideration both the geometry and the optics of its components. The collector is placed within the focal region of the concentrator, in the diagonal plane between two conical secondary mirrors forming an open box. The concentration coefficient of the heat collector, which it owes to these two mirrors, the outer larger one reflecting radiation from the concentrator back into the inner smaller one and the latter rereflecting this radiation onto the heat collector, is calculated on the basis of the complete radiant flux balance in the system. An expression is obtained for this coefficient as a function of the angle of incidence and the ratio of collector wall thickness to collector height, with the reflection coefficient of the secondary mirrors and their opening angles as parameters. For a collector made of Kh18Ni10Ti stainless steel with a 0.9-0.93 absorption coefficient and a 0.22-0.28 emissivity of the surface, this expression yields a concentration coefficient which varies from 6 to 19 as the ratio of collector wall thickness to collector height is reduced from 0.8 to 0.2, when the reflection coefficient of both secondary mirrors is 0.9 and the angle of radiation is 80°. This relation was verified experimentally in an autonomous 0.5 MW solar heating plant with a hollow cylindrical heat collector 120 mm in diameter and 90 mm in height. Figures 3; references: 4 Russian. [167-2415]

DETERMINING HEAT LOSSES AND COEFFICIENT OF HEAT TRANSMISSION THROUGH LATERAL STEEL WALLS OF SOLAR WATER HEATING TANK

Tashkent GELIOTEKHNIKA in Russian No 6, Nov-Dec 84 (manuscript received 8 Jun 83) pp 41-43

AVEZOV, R.R., URUMBAYEV, A.Kh., SERDYUK, V.V. and KAKHAROV, N.A., Institute of Engineering Physics imeni S.V. Starodubtsev, UzSSR Academy of Sciences, and UzSSR Ministry of Installation and Special Construction Work

[Abstract] The coefficient of heat transmission through the lateral steel walls of a solar water heating tank is calculated on the basis of the heat balance, assuming that a rubber II-seal insulates the tank structure from the heat collector. Into account are taken heat losses by absorption. The resulting

relation indicates that this coefficient increases linearly with increasing heat transfer coefficient at the outside wall surface. Figures 2; references: 1 Russian.
[167-2415]

UDC 662.997:621.316.544.4

KINETICS OF ACTION OF CONCENTRATED SOLAR ENERGY ON VARIOUS MATERIALS

Tashkent GELIOTEKHNIKA in Russian No 6, Nov-Dec 84 (manuscript received 13 Sep 82) pp 48-53

DVERNYAKOV, V.S., Institute of Problems in Materials Science, UkSSR Academy of Sciences

[Abstract] Heat treatment of various materials with concentrated solar energy is analyzed, considering that the action of solar energy is based on a nonmonochromatic volume effect and thus differs fundamentally from the action of an electron beam or a laser beam. An advantage of solar heat treatment is that its dependence on the space-time characteristics of the source becomes irrelevant and that it can be effected in the pulsed mode as well as in the continuous mode. The kinetic characteristics of solar heat treatment at the ceiling level of 2 kW/cm^2 with special heliostats are compared with those of laser treatment at the floor level of 10 kW/cm^2 ; as a frame of reference, the basic two characteristics are the time and the attainable temperature gradients required to heat a material to its melting point. Industrial materials included in this survey are metals (Al, Cu, steel, Ni, Ti, Cr, Mo, W), as well as refractory oxides, carbides, and nitrides. The critical values defined are those at which high-temperature surface breakdown as a result of phase transition occurs. The behavior of metals is characterized by stabilization of the surface temperature, after a transient period, above the melting point when the radiant flux intensity exceeds the phase transition threshold. Accordingly, the melting front as an interface between solid and liquid phases shifts then deeper into the material. The behavior of nonmetallic materials is characterized by a narrowing of the zones of physical and chemical transformations as the heat load is increased but the exposure time remains the same. Accordingly, the transformation front within the volume then shifts toward the surface here, at different speeds in different materials. This trend continues only till the radiant flux intensity reaches the phase transition threshold, above which the heat balance changes. A quantitative analysis for non-metallic materials is based on the approximation of an optically thick or semitransparent layer. The particular solution to the Fourier equation is obtained for the Stefan condition at the liquid-solid interface and, as a linear function of the corresponding Gauss error integral, yields the equation of kinetics of physical and chemical transformations. Figures 3; tables 2; references: 4 Russian.
[167-2415]

SUBSTATIONS OF EKIBASTUZ-CENTER 1500 kV ELECTRIC POWER TRANSMISSION LINE

Moscow ELEKTRICHESKIYE STANTSII in Russian No 12, Dec 84 pp 38-42

BERKOVSKIY, A.M., engineer, LYASHENKO, V.S., engineer, and NAZAROV, A.M., engineer, All-Union State Design, Surveying and Scientific Research Institute of Power System and Electrical Networks

[Abstract] The first d.c. transmission line is now under construction, a 1500 kV line for transmitting electric power in the east-to-west direction from Ekibastuz to Tambov in the Central Region. This is a 2414 km long overhead line with a power capacity of 6000 MW per circuit. An important and unique part are its two terminal substations with a.c.-to-d.c. and d.c.-to-a.c. converting equipment, respectively. On the a.c. side at both ends are two parallel 12-phase 1500 MW branches, each consisting of two 750 MW - 375 kV - 2000 A stages. Conventional auxiliary equipment includes transformers, regulators, and protective relays with automatic control. An innovative feature is separation of functional capacitor banks into compensators of reactive, operating in tandem with synchronous rotating capacitors, and filters of current harmonics. Paper-film capacitors with a synthetic impregnant are used for filtering, and cosinusoidal capacitors are used for compensation. It has been found feasible to install four smaller instead of two larger filter banks and to eliminate standby in the phases. Synchronous rotating compensators are connected to 500 kV distribution busbars; their total power needs not be more than 25% of installed static compensator power. These and other features result in smaller short-circuit currents, higher level of readiness and reliability, lower fixed and operating cost, less equipment for the 500 kV overhead feeder lines, and, with series inductive reactors in the filter circuits, a better current waveform in those feeder lines. Also less costly air circuit-breakers can be used, and less right-of-way territory is required for the substation equipment. Figures 3; references 4: 2 Russian, 2 Western.
[176-2415]

ORGANIZATION OF STARTUP AND DEBUGGING IN 1200 MW POWER UNIT OF KOSTROMA STATE REGIONAL ELECTRIC POWER PLANT

Moscow ENERGETIK in Russian No 1, Jan 85 pp 7-8

BATUNOV, G.K., engineer, BOGACHKO, Yu.N., engineer, VIKHREV, Yu.V., candidate of technical sciences, and ZUBOV, I.V., engineer deceased, All-Union Technical Administration of Power System Management, Kostroma GRES, All-Union Institute of Heat Engineering imeni F.E. Dzerzhinskiy

[Abstract] The first 1200 MW power unit of the Kostroma GRES required only a short period for startup and then break-in under nominal load, because all preparatory work had been well organized. Experience with 800 MW power units

of the Zaporozhye GRES and the Uglegorsk GRES served as the basis for the program of operations designed at the Korkiy branch of the Institute of Atomic Thermal Electric Power System Design, with the assistance from the All-Union Technical Administration of Power System Management. The instrumentation for testing and monitoring, with "Orion-M" cathode-ray oscilloscopes as indicating devices, was the same which the Central Scientific Research Institute of Complex Automation had already developed for thermal electric power plants. All auxiliary equipment and parts were designed or purchased to custom specifications and thoroughly inspected upon delivery to the site. The power unit was tested and, after necessary revisions of the metal components especially, retested for fitness before actual startup.
[192-2415]

UDC 621.91:669.018.25:020.9

USE OF ADVANCED HARD ALLOYS IN POWER MACHINERY MANUFACTURE

Moscow ENERGOMASHINOSTROYENIYE in Russian No 2, Feb 85 pp 15-16

ADAM, Ya.I., candidate of technical sciences, and KLAUCH, D.I., candidate of technical sciences

[Abstract] Large polyhedral nonregrindable tool bits made of hard alloys with or without wear-resistant coating are used at the Leningrad Metal Works and by the "Atomash" (Atomic Machinery Manufacturing) Industrial Association. Specific grades are selected for continuous rough, semifine, or fine turning and boring, intermittent rough-case or fine turning, boring and milling, respectively. Titanium alloys TK, TTK and vanadium alloys VK, VP are used for machining plain carbon steels and stainless steels, vanadium alloys VK, VK-OM, VK-KhOM are used for machining gray cast iron, the same vanadium alloys and one titanium alloy (Ti5K6) are used for machining special steels: corrosion-resistant, heat-resistant, high-silicon electrical, high-manganese, titanium, etc. Cutting depths of 15-18 mm in alloy steel with 220-240 Brinell hardness are attainable at cutting rates of 1.3-1.8 mm/rev and feed rates of 60-120 m/min, with a tool life of 1- 1.5 h. Tables 3; references: 2 Russian.
[193-2415]

STEAM TURBINES PRODUCED AT LENINGRAD METAL WORKS FOR HEAT AND ELECTRIC POWER PLANTS

Moscow TEPLOENERGETIKA in Russian No 12, Dec 84 pp 10-15

VOLKOV, O.D., engineer, NEZHENTSEV, Yu.N., engineer, and LISNYANSKIY, F.A., engineer, Turbine Design Department, Leningrad Metal Works

[Abstract] Three models of steam turbines for heat and electric power generating plants are now produced at the Leningrad Metal Works. The R-50/60-130/13 is a single-cylinder turbine with backpressure for driving a.c. generators and supplying industrial heat with 0.685-2.06 MPa steam at rates of up to 420 t/h; its rating is 52.7 MW nominal power and 60 MW maximum power at 3000 rpm, with 555°C - 12.75 MPa steam. The PT-80/100-130/13 is a 2-cylinder condenser turbine for supplying industrial heat; its rating is 80 MW nominal power at 3000 rpm, with 555°C - 12.75 MPa steam. The T-180/210-130 is a new 3-cylinder turbine; its rating is 180 MW nominal power and 210 MW maximum power at 3000 rpm, with 540°C - 12.75 MPa steam. This turbine is an updated version of the K-210-130, also produced at the Leningrad Metal Works, with an intermediate superheating stage and with K-300-240 and T-250/300-240 components for partial standardization and high economy of the low-pressure stages. Other turbine models are being considered for production, to meet special requirements by foreign customers which depart from USSR practice. Figures 5; tables 1; references: 7 Russian.
[174-2415]

RAISING THERMAL AND ELECTRIC POWER OF T-250/300-240 TURBINE BY PARTIAL DISPLACEMENT OF REGENERATIVE STEAM AT TAP POINTS IN HIGH-PRESSURE SUPERHEATER

Moscow TEPLOENERGETIKA in Russian No 12, Dec 84 pp 30-32

SAKHAROV, A.M., engineer, TAZHIYEV, E.I., engineer, and BARINBERG, G.D., candidate of technical sciences, Planning Department, State All-Union Engineering Administration of Power Systems; Moscow Regional Administration of Power System Management; Planning Department, Tomsk Metal Works

[Abstract] Artificial reduction of steam drawn high-pressure superheaters for regenerative purposes is considered as means of increasing the available electric and heating power with an additional improvement of the fuel economy; this steam is used for heating the feedwater and reducing the heat loss in the condenser with cooling water. Partial bypassing of all superheaters in the group rather than only a part of the group has been found to be the only viable method of steam displacement which will neither reduce the reliability nor result in steam drain and air suction. The maximum permissible attendant pressure rise in the turbine steam passages and in the intermediate heater

had to be determined first, in order to establish the maximum feasible amount of feedwater allowed to bypass superheater tube bundles. This was done on a T-250/300-240 turbine with an oil-heated boiler at the Tomsk Metal Works in a series of tests involving measurement of electric power by the two-wattmeter method, of feedwater and live steam flow rates with differential manometers, of heat load on the basis of feedwater and condensate flow rates, of steam pressure at critical locations, and of steam temperature at critical locations. These tests were performed during the 15-24 February 1984 period, with the turbine operating according to the heat chart at nearly nominal intake of live steam and with the feedwater heated in two stages. Each series consisted of two tests, with the bypass valve fully open in one and fully shut in the other under a constant steam rate. An evaluation of the results, with reference to overall plant operation data, indicates that steam displacement by partial bypassing is economical and reliable. The scheme has been implemented in the TETs-21 and will be adapted for all turbines of one type in the TETs-26; both heat and electric power plants are in the Moscow regional power system. Figures 1; tables 1.
[174-2415]

UDC 621.311.22.002.51.66.012.1

DATA SYSTEM FOR INDICATING STATE OF COOLANT IN 300 MW POWER UNITS

Moscow TEPLOENERGETIKA in Russian No 12, Dec 84 pp 42-46

ZHIVILOVA, L.M., candidate of technical sciences, SHCHERBAKOVA, K.N., engineer, FOMICHEV, Yu.P., engineer, PEREKHOZHEV, S.V., engineer, and MOGILEVSKIY, D.I., engineer, All-Union Institute of Heat Engineering and Konakova GRES

[Abstract] A system of data display for water treatment control in the Konakovo GRES, indicating the state of the coolant and any changes in its performance in the eight 300 MW power units, has been developed on the basis of a statistical analysis covering many years of plant operation. The parameters which must be measured for effective control are electrical conductivity, pH, Na content, O₂ content, H₂ content, and SiO₂ content. Each of these parameters is measured by a corresponding instrument with appropriate range and accuracy. The function of the ohmmeters with H-prefilters, and of redox meters, is to automatically indicate necessary doses of ammonium and hydrazine used as corrective treatment reagents. Rational installation and operation of this data display system has made it possible to effectively reduce the corrosion rate and the scale buildup in the turbine of power unit No 7. The data processing system includes analyzers and secondary recording instruments, an M-43 central control computer with printout, and two cathode-ray tubes for display. These display tubes are mounted, one on the modular chemical-inspection panel and one on the chemical-purification control panel. The computer input/output device serves both as commutator of analog signals and as analog-to-digital converter. With such a single central device, the noise immunity of the transmitted information would be low, but this can be remedied by distributing its function over all modules of the chemical-inspection panel

so as to shorten the length of the transmission paths for digital data and thus reduce the noise pickup level. A further improvement is achieved by use of fiber-optic cables. The database with constant output data (names of parameters, units of measurement, mnemonic information) and variable output data (description of parameters) as well as the program are stored in the computer memory along with the functional keying array. The variable readout from the input/output device is scaled and converted into the standard ASCII code. Further improvements are made for eventual use of an SM-4 mini-computer in the OCRSX operational system for execution of the inspection and control program. Figures 4; tables 2; references: 1 Russian.
[174-2415]

INDUSTRIAL TECHNOLOGY

ROBOT DRIVE MECHANISM USES CONVENTIONAL ELECTRIC MOTORS

Moscow SOTSIALISTICHESKAYA INDUSTRIYA, 16 May 85, p 4

DEMCHENKO, I.

[Excerpt] Scientists of the All-Union Scientific Research Institute of Electric Drives (VNIIElektroprivod) have proposed using ordinary three-phase, asynchronous electric motors in robot technology. Such motors are produced by the millions in our country. At the Institute of Electric Welding imeni Paton, they have undergone initial tests in a welding manipulator, and tests are now continuing.

What is new in this idea of the VNIIElektroprivod specialists? And if such motors are widely used in industry, why are tests still necessary? We asked Candidate of Technical Sciences V. Mishchenko, head of the group of developers, to respond to these questions.

"This only seems to be a paradox," related Vladislav Alekseyevich. "After all, such motors have not been employed in robotics before. Mechanical helpers are usually equipped with special DC electric motors. And not without reason; these motors are almost always preferred when speed and force must be regulated. This is because they are substantially more complex in design, but on the other hand they are quite simple to control, and they carry out commands quickly and precisely. But the cost of these motors is high.

"After all, a robot needs more than one drive; its mechanical arm has as many drives as it has 'joints.' Manipulators in use in modern industry must possess six to nine degrees of mobility, and experimental prototypes with 18 coordinates of movement are already being developed. More and more motors are needed.

"This is why it is an attractive idea to place one of the simplest, most common and most inexpensive electric motors in industry at the service of robotics. Up until now, this motor has been considered unsuitable for delicate work because of its low precision in executing commands and the difficulty of controlling it. We have managed to bend this stubborn motor to our will by developing control methods that are new in principle. This has made it possible to employ in robots a motor that has been in use for about 100 years.

"Integrated microcircuits and a power converter are placed on two printed circuit boards 20 by 30 centimeters in size. This unit controls the operation of a single motor, and a cassette made up of six units controls the operation of the whole 'mechanical arm.' This cassette is linked with the robot's 'brain'--a microprocessor system or microcomputer."

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CSO: 1861/282

LASER TREATMENT AND MACHINING TECHNOLOGY FOR AUTOMOTIVE INDUSTRY

Moscow SOTSIALISTICHESKAYA INDUSTRIYA, 14 May 85, p 1

SHVORINA, V. (Moscow)

[Excert] Our country's first automatic line for laser thermal hardening of parts has been handed over for experimental-industrial operation in the engine building of the chief plant of the "Automotive Plant imeni Likhachev" (AvtoZIL) Production Association.

"All of the country's major automotive plants are successfully introducing laser technology," related S. Podsoblyayev, director of the Scientific Research Institute of Technology for the Automotive Industry (NIITavtoprom). "The economy is reaping tremendous gains from this; spare-parts production is being sharply reduced, a large amount of metal is being saved, and production standards are rising."

The use of lasers has made it possible to obtain surfaces whose wear resistance is heightened by at least two times, to weld parts whose joining was out of the question in the past, and to cut superhard and soft materials with a precision and speed which was formerly unattainable.

About 50 lasers of various types are now operating at plants of the industry. The expansion of both the geographical distribution of laser technology and production processes and their sphere of application is planned during the coming 5-year plan. The light beam will cut templates, facing materials, plywood and plastic materials, pierce holes, alloy metals, and weld and harden automotive assemblies and parts and blanking and cutting tools. It is proposed to introduce 100 units similar to the one that has been put into operation at ZIL, for example.

"Up until recently, crosspieces between internal-combustion chambers of the cylinder block were an achilles' heel in the heart of our 'ZIL' vehicles," related V. Kal'ner, deputy chief engineer of the association. "These connectors burned through rather quickly from the effect of high temperatures, and engines failed."

Associates of the central laboratory of electron-beam and laser treatment at "ZIL" were joined by specialists of NIITavtoprom, the "Elektronika" Central

Scientific Research Institute, Moscow State University and the USSR Academy of Sciences' Scientific Research Center for Industrial Lasers. Attempts were made to subject inter-chamber crosspieces to local treatment with a light beam. These experiments yielded encouraging results: the durability of the pieces was more than doubled.

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ACADEMY OF SCIENCES' INSTRUMENT BUILDING ASSOCIATION

Leningrad LENINGRADSKAYA PRAVDA, 20 Apr 85, p 2

MANILOVA, Zh.

[Excerpt] The USSR Academy of Sciences' Scientific-Technical Association (NTO) in Leningrad is now one of the largest organizations in the academy's system. Created a few years ago on the basis of the Special Design Bureau of Analytical Instrument Building, the association is called upon to fulfill an extremely important need--equipping basic science with essential instruments and equipment or, to be more specific, with high-precision instruments and highly sophisticated equipment for studying the composition and structure of matter.

A highly developed scientific-instrument building industry is needed today. Nothing less than an industry, and that is why the NTO takes in not only the institute and special design bureau of analytical instrument building, but also the Central Design Bureau of Unique Instrument Building, the Special Design Bureau of Biological Instrument Building, an experimental production enterprise and a number of plants.

On the desk of Maksim Leonidovich Aleksandrov, general director of the association, lay a folder containing inquiries to be answered. They were from prominent foreign firms that wished to acquire instruments developed in Leningrad.

Various types of equipment shipped from the NTO are being used in many of the world's research laboratories. Scientists of Yale University in the USA and the Institute of X-Ray Diffraction Analysis in Austria are very pleased with this equipment, as are researchers of the Pasteur Institute in France and scientific institutions of socialist countries.

(A photograph is given showing Candidate of Physical-Mathematical Sciences N. A. Kholin, engineer M. V. Stepanov, and V.P. Kalinin, head of an assembly shop, adjusting a unit for growing and studying structures for semiconductor technology, which was developed jointly with scientists of the Physical-Technical Institute.)

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CSO: 1861/258

SOVIET-CZECHOSLOVAK ROBOTICS ASSOCIATION ESTABLISHED

Moscow EKONOMICHESKAYA GAZETA, 8 Apr 85, pp 12, 13

[Abstract] Two full pages of articles are given featuring the International Scientific-Technical Association "Robot" that has been established by the USSR and Czechoslovakia. On March 22, the governments of the two countries signed an Agreement on Collaboration in the Development of Robot-Equipped Complexes and Flexible Production Systems, in conjunction with which the international association was established.

Excerpts from the association's charter are given, stating its objectives, identifying its membership, and defining its management apparatus. Among the association's goals are the elaboration of technical concepts for robot-equipped complexes and flexible production systems; determining the needs of both countries and of interested third countries for such complexes and systems; and preparing recommendations for the specialization and sharing of production of complexes and systems. Other excerpts give information on the association's financing and management. Overall management is to be exercised by a Council of Plenipotentiaries, which has equal representation on both sides. On the Soviet side, the council is headed by a representative of the USSR State Committee for Science and Technology, and on the Czechoslovak side by a representative of the State Commission on Scientific-Technical and Investment Development. The sides share in the financing on an equal basis.

Separate articles are included which report on directions of work by the association and identify its participating enterprises, institutes and other organizations. The articles are by: Vladimir Cop, deputy chairman of the Czechoslovak Socialist Republic's State Commission on Scientific-Technical and Investment Development; A. F. Kamenev, deputy chairman of the USSR State Committee for Science and Technology; and USSR Minister of the Machine Tool Building and Tool Industry B. V. Balmont.

An organizational diagram of the "Robot" association is also given.

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AIR-HYDROGEN ELECTROCHEMICAL GENERATOR

Moscow NEDELYA, 25 Apr-5 May 85, p 4

DANILOVSKIY, F. (Moscow)

[Excerpt] Soviet scientists have developed an original air-hydrogen electrochemical generator (EKHG) which can replace storage batteries in many instruments and apparatuses. Moreover, broad employment of this device will save a large amount of scarce nonferrous metals that are needed also for the production of small electric batteries. It is based on so-called fuel cells in which chemical energy is converted into electrical energy.

Design complexity and high production cost long prevented the original idea for such cells from being embodied in experimental prototypes. A working model of a fuel cell was not developed until the 1960s. Now generators developed on the basis of such cells can be serially produced. Such a generator is dependable and simple to use, and it performs well in different kinds of field conditions. It can be carried from place to place in a backpack.

The generator's efficiency can be as high as 70 percent. This opens up broad possibilities for employing such generators in electric motor vehicles.

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CSO: 1861/258

QUANTITATIVE ESTIMATION OF DIVERSITY BETWEEN OBJECTS OF STANDARDIZATION IN
DESIGN OF FLEXIBLE AUTOMATIC PRODUCTION

Moscow STANDARTY I KACHESTVO in Russian No 12, Dec 84 pp 9-14

AMIROV, Yu.D., candidate of technical sciences, All-Union Scientific Research
Institute of Machine Design, and SYSOYEV, V.B., engineer, Industrial Association
"Kirov Plant"

[Abstract] The degree of similarity or diversity between complex objects to be standardized for flexible automatic production is estimated quantitatively, in accordance with the statistical information theory based on Hartley's and Shannon's relations. The procedure is demonstrated using the simple case of two parts. Both are to be machined, and they are compared with respect to a single characteristic dimension, typically their diameter. First the diversity of one part relative to the other is determined when they have different diameters. Then the diversity of one part relative to the other is determined when they have the same nominal diameters but with different tolerances. Finally the most general situation in this case is considered, namely diversity between the two parts when their diameters and the tolerance on the diameters are different. The results can be applied to the design of a flexible automatic production system, where the complexity of control and regulation depends on the multimodality and the indeterminacy of processes rather than on the complexity of the system. Quantitative diversity estimation yields a measure of the final product relative to the original blank. The reverse problem is to design the machining operations for converting parts from blanks to final products within prescribed limits of diversity. Figures 2; references 7: 6 Russian, 1 Western (in Russian translation).
[177-2415]

COMPOSITE COEFFICIENT CHARACTERIZING EFFECTIVENESS OF FLEXIBLE AUTOMATIC PRODUCTION SYSTEM IN MACHINING OF PARTS

Moscow STANDARTY I KACHESTVO in Russian No 12, Dec 84 pp 14-15

VEYTSMAN, E.V., candidate of technical sciences, and VENBRIN, V.D., candidate of technical sciences

[Abstract] A composite coefficient is proposed for characterizing the effectiveness of a flexible automatic production system in machining parts. This coefficient is $K_{T,FAP} = \alpha_1 K_1 + \alpha_2 K_2 + \alpha_3 K_3$. Here $K_1 = P(T)/P_T$ accounts for repeatability (seriality) of the final product, $K_2 = P_S/P_{FAP}$ accounts for standardization of parts, and $K_3 = P_{FAP}/P_M$ is the ratio of parts processed by the flexible automatic production system to parts processed altogether by machine tools (P_T - number of standard dimensions of parts in given product, $P(T)$ - number of standard dimensions of parts in given product with degree of repeatability economically justifying flexible automatic production, P_{FAP} - total number of parts in given product processable by flexible automatic system, P_M - total number of parts in given product to be machined, P_T and P_M excluding standard fasteners). Ranking as well as absolute and relative prioritization, with the aid of expert estimates, yield $\alpha_1 = 0.17$, $\alpha_2 = 0.50$, $\alpha_3 = 0.33$ so that $K_{T,FAP} = 0.17K_1 + 0.50K_2 + 0.33K_3$. Effectiveness of flexible automatic production is rated very low when $K_{T,FAP} = 0-0.2$, low when $K_{T,FAP} = 0.2-0.4$, medium when $K_{T,FAP} = 0.4-0.6$, high when $K_{T,FAP} = 0.6-0.8$, and very high when $K_{T,FAP} = 0.8-1$. References: 3 Russian. [177-2415]

UDC: 621.313.323

ANALYSIS OF ARTIFICIAL DAMPING OF INDUCED OSCILLATIONS OF SALIENT- POLE SYNCHRONOUS LONGITUDINAL-TRANSVERSE EXCITED MOTOR BY ROCKING MAGNETIC FIELD

Tashkent IZVESTIYA AKADEMII NAUK UZBEKSKOY SSR: SERIYA TEKHNIЧЕСКИХ НАУК in Russian No 6, Nov-Dec 84 (manuscript received 3 Jul 84) pp 22-26

AKHMATOV, M.G., Tashkent Order of People's Friendship Polytechnical Institute imeni Abu Raykhana Beruni

[Abstract] Periodic load changes on the shaft of the motor driving a powerful piston-type gas compressor can be reduced by the use of flywheels or by changing the pulsating excitation in the longitudinal or in both axes of the drive motor. The excitation regulation rule should ensure complete damping of rotor oscillations by varying excitation of the transverse winding. The load moment must be balanced at each instant by the electromagnetic moment of the motor. Presence of the transverse exciter winding, which is fed by a rocking frequency current, makes it possible to create a rocking field to achieve this balance. Equations are derived for computation of the magnetic field necessary to balance the forces. Figures 2, references 2 Russian. [252-6508]

MULTIPLE-ROTOR ASYNCHRONOUS MOTOR WITH MASSIVE TUBULAR ROTORS

Tashkent IZVESTIYA AKADEMII NAUK UZBEKSKOY SSR: SERIYA TEKHNICHESKIKH NAUK
in Russian No 6, Nov-Dec 84 (manuscript received 28 Sep 83) pp 26-29

ISAMUKHAMEDOV, Z.Sh., KHADZHINOVA, M.U., Institute of Power Engineering and
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[Abstract] A study is made of the correlation among the processes which occur in massive rotors and the parameters of a motor influencing its impedance. The calculation method, based on the equations of Maxwell, allows determination of the electrical and magnetic field intensities and current density in a massive rotor. The magnetic and electric fields arising as a result of the traveling magnetic field created by a three-phase current in the stator winding of an asynchronous motor with massive steel rotors are described by Maxwellian differential equations, which are simple and symmetrical for a homogeneous linear medium. The equations are solved on the assumption that the distribution of magnetic induction along the rotor axes is uniform, the influence of the head ends on electromagnetic processes in the active zone can be ignored, all rotors are reduced to a single rotor, the major spatial harmonic of the magnetic field in the air gap is studied and hysteresis losses can be ignored. The mechanical characteristics, power factor and efficiency of such motors can be improved by decreasing the relative magnetic permeability, increasing magnetic circuit saturation, using steel with reduced resistivity and metal rotor surface coating such as thin layers of copper, using windings with reduced head and impedance and making slots along the rotor cylinder generatrix to increase the total current conducting area, decreasing active resistance. Figure 1, references 4 Russian.
[252-6508]

METHOD OF AERODYNAMIC DESIGN ON CYLINDRICAL CHAMBER WITH WHIRLING OF COOLANT STREAM

Minsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ENERGETIKA in Russian No 2,
Feb 85 (manuscript received 26 Apr 83) pp 86-90

SABUROV, E.N., professor, and LEUKHIN, Yu.L., "Order of Labor Red Banner"
Arkhangelsk Institute of Forestry Engineering imeni V.V. Kuybyshev

[Abstract] The aerodynamic design of a cylindrical heating chamber with whirling of the coolant stream and peripheral discharge of gases is considered on both a theoretical and an empirical basis. The plane jet of coolant at the chamber wall is described by corresponding three equations of a turbulent boundary layer, assuming an incompressible gas and a constant radius of longitudinal surface curvature, while including the effects of longitudinal

and transverse pressure gradients. These equations, together with the equation of continuity, reduce to two integral relations for the ratio of skin-frictional stress to coolant density. An empirical relation for the thickness of the hydrodynamic boundary layer closes this system of equations. Solution of the latter is based on an evaluation of the drag coefficient and the boundary layer thickness from experimental data by the method of dimensional analysis and according to the theory of similarity. Article was presented by Department of Heat Engineering. Figures 3; references 8: 7 Russian, 1 Western.
[169-2415]

UDC 020.178.3:539.43

FATIGUE DEFECT TRANSDUCER AND VALIDATION OF ITS USABILITY: REPORT NO 1

Kiev PROBLEMY PROCHNOSTI in Russian No 1, Jan 85 (manuscript received 19 Jan 84)
pp 3-8

TROSHCHENKO, V.T. and BOYKO, V.I., Institute of Strength Problems, UkSSR Academy of Sciences, Kiev

[Abstract] A technology of producing a fatigue defect transducer and a methodology for using it for reliable prediction of performance margin and available life of structures have been developed on the basis of irreversible changes in the electrical resistance of metals under cyclic strain. Actually such a transducer indicates the history of cyclic loading and the term "fatigue defect transducer" is a misnomer used tentatively only. The first transducer of this kind in the USSR, featuring excellent metrological characteristics along with small size and simple design, also not requiring continuous connection to intricate measuring and recording instruments, has been built with annealed constantan foil according to the technology of conventional KF4 resistive strain gauges. Its main characteristics are base size 5.0 mm, initial electrical resistance 94-105 ohms, operating range of resistance variation 0.5-6.0 ohms with 5-30% variance, operating temperature range 103-308 K, operating range of cyclic strains 0.0011-0.0025 with 0.0011 as the sensitivity threshold, operating range of static strains 0-(+0.0040), and endurance limit 0.0013-0.00245 on the base of 10^7 - 10^5 cycles. In practice the lines of constant transducer resistance change do not always coincide with the fatigue curves of the monitored object. When the fatigue curves lie above the operating range of the transducer (R_{\max} =6.0 ohms line), then the latter will fracture before the object does. When the fatigue curves lie below the operating range of the transducer (R_{\min} = 0.5 ohm line), then the object will fracture before the transducer resistance has varied by an accurately measurable amount. Therefore, the transducer is effective only when the fatigue curves of a material lie within the operating range of the transducer. This requires extending that range, by means of a device for attenuating or amplifying the transducer strain under a given object strain. It is advisable to install the transducer not within the inspection zone but farther away, where the load is a known fraction of the maximum, and add a strain multiplier. Such

a device is an extension rod passing through a rubber pad and glued onto the transducer base; its gain ranges from 1.5 to 4.0 for practical applications; the transducer sensitivity is raised proportionally. The design and performance evaluation of this transducer take into account all four principal influencing factors: load frequency, cycle asymmetry, ambient temperature, and stress concentration. The transducer has been calibrated for use on objects made of 06Cr steel, D16T aluminum alloy, VT6 titanium alloy, AD33 aluminum alloy, St.45 steel and St.3 steel. The strain multiplier was designed and the dependence of transducer readings on the load frequency was evaluated with the assistance of S.G. Orlov. Figures 5; tables 1; references 9:
7 Russian, 2 Western.

[182-2415]

UDC 681.142.622

STABILIZER OF SHAFT ROTATION ANGLE FOR D.C. COMMUTATOR MOTOR

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 84 (manuscript received 3 Oct 83) pp 230-231

NIZOVOY, S.N., KULIDZHANOV, F.G. and YELYUTIN, N.O.

[Abstract] A stabilizer of shaft rotation angle for d.c. commutator motors is described which suppresses speed fluctuation caused by a change in the armature current as successive commutator bars reach the leading edge of a brush. This is achieved by inserting a low series resistance into the armature circuit and feeding the voltage across it to a servo oscillograph so that the frequency of the driven sweep becomes a multiple of the shaft speed. Return-stroke sweep pulses are extracted from the sawtooth voltage wave by a shaping circuit which consists of one capacitor, one resistor, two diodes, and one trigger. After a specified number of pulses has accumulated, another trigger actuates a switch which disconnects the motor from the voltage supply. A single starting pulse at the output of another shaping circuit records a specified number in the same pulse counter, through arrays of switches, and sets the same trigger for reconnecting the motor to the voltage supply. This stabilizer was tested on a positioning table driven by an MN-250 motor with 6-bar commutator, using an S1-19B oscillograph. The motor was started in steps for rotation in 3' steps, and the table position was measured after each 20 steps by means of a theodolite within $\pm 4''$ accuracy. The average instability of the rotation angle between measurements did not exceed $\pm 30''$. Figures 2; references: 4 Russian.

[107-2415]

DESIGN OF VIBRATION MACHINES WITH INERTIAL EXCITATION

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian
No 1, Jan-Feb 85 (manuscript received 17 May 84) pp 59-66

BOLOTNIK, N.N., Moscow, and NGUEN CHYONG, Hanoi/VIETNAM

[Abstract] A perfectly solid platform which is horizontal when at rest is mounted on a stationary foundation between two walls through two pairs of generally unequal springs; the foundation springs limit its vertical motion and the wall springs limit its horizontal motion. This platform is set in plane-parallel motion by an inertial vibration exciter mounted on it and consisting of two identical unbalanced rotors which spin in opposite directions at the same constant speed on a common shaft, this shaft being horizontal so that the platform moves in the vertical plane only. The problem is formulated in two systems of Cartesian coordinates, a movable one and an inertial one with a common origin at the point at one end of the platform where one set of springs is attached. The x,y axes of the inertial system remain, respectively, horizontal and vertical, while x-axis through the point at the other end of the platform where the other set of springs is attached and the y-axis perpendicular to it move with the platform. The motion is described in terms of kinetic energy and potential energy, whereupon small vibrations of the platform are considered which allow, with sufficient accuracy, linearization of the corresponding Lagrange equations. The design problem is to find a set of values of the system parameters which will ensure stable 2-periodic vibrations of the system corresponding to translatory motion of the platform; such a motion occurs only when the orientation of the movable x-axis relative to the inertial (horizontal) x-axis remains constant. In the simplest case the movable x-axis also remains horizontal and here, just as in the more general case of an inclining movable x-axis, there are three cases of special interest with a respectively 0, 90°, 45° angle between exciter action line (bisector of angle between the two lines from the centers of inertia of the two rotors to the common shaft) and the movable x-axis. As a specific example is considered a vibration pad for reinforced-concrete products. Design formulas are derived for the six basic parameters: four spring constants, assuming that all springs have a linear stiffness characteristics, and two coordinates in the movable system defining the location of the shaft of both rotors relative to the platform. Three of these parameters, namely the distance from the exciter shaft from the platform y-axis and the spring constants of the two wall mountings, allow an arbitrary selection of values; this contributes to design flexibility. The authors thank B.V. Gusev and Ye.Z. Akselrod for discussing formulation of the problem and results. Figures 3; references: 6 Russian.

[189-2415]

EFFECTIVENESS OF STRUCTURAL COUNTERMEASURES FOR REDUCING BLADE VIBRATIONS
EXCITED BY RANDOM FLOW FLUCTUATIONS

Kiev PROBLEMY PROCHNOSTI in Russian No 1, Jan 85 (manuscript received
22 Mar 84) pp 51-53

BAVELSKIY, D.M., BOGORADOVSKIY, G.I., GURSKIY, G.L. and POMANYCHEV, M.S.,
Leningrad

[Abstract] A study of blade vibrations in the prototypes GTN-25 gas pumping set by the discrete-phase method had revealed such vibrations in the first stage of the high-pressure compressor, vibrations at frequencies not multiples of the runner speed as well as normal resonance vibrations. These anomalous occurred throughout the entire range of runner speed; their intensity increased with that speed. Readings of low-inertia pressure fluctuation transducers placed before the guide vanes on the compressor inlet side and spectral analysis of these readings, aided by visual inspection and analysis of compressor-turbine aerodynamics, indicated an absence of flow separation as the possible cause. Instead, they indicated a nearly "white noise" distribution of those fluctuations, with a predominance of random fluctuations in the low-frequency range and characterized by a background level comparable with or even exceeding the level of runner speed harmonics. Their occurrence was attributed to high vorticity of the gas stream at the compressor inlet, owing to design deficiencies. The remedy then proposed and implemented was a buildup of the inlet tube for smoothing its surface contour along the stream and a reorientation of the channel walls to make them parallel with the stream boundary. The latter was achieved by insertions of a ring with triangular cross-section so as to deflect the stream along its hypotenuse and thus reduce the effect of the pocket behind it. These countermeasures were found to reduce the level of random fluctuations by approximately 20 dB, at the same level of runner blade harmonics. Figures 4.

[182-2415]

EXTENDING RANGE OF STABLE OPERATION OF AXIAL COMPRESSORS BY MEANS OF SELF-
ROTATING INLET GUIDE VANES

Moscow ENERGOMASHINOSTROYENIYE in Russian No 2, Feb 85 pp 7-9

KNYAZEV, V.S., doctor of technical sciences [deceased], and ZHOKHOV, V.L.,
candidate of technical sciences

[Abstract] An array of self-rotating guide vanes has been developed for axial compressors. Its purpose was to extend the range of stable operating speeds. Its characteristic feature is that the vanes, made of steel strip,

have a biconvex S-profile so that the array in effect behaves as a combination of aerodynamically matched compressor and turbine mounted on the same shaft and rotating at the same speed. Two designs were tested, and their performance was evaluated over the 750-1000 rpm range of runner speed, with the Mach number of the air stream $N_M = 0.1-0.12$ and with the Reynolds number $N_R = (1.8-2.0) \cdot 10^5$. The theoretical pressure coefficient was calculated from torque readings taken on a d.c. balancing dynamometer. The flow coefficient was calculated from readings of the air rate at the inlet. The runner speed and the speed of the vanes were measured by the contactless method with stroboscope and markers. The results reveal that, by decreasing the pressure coefficient slightly to 0.015, it has been possible to lower the cutoff air rate by 9.4-1.2% and the cutoff runner speed by 13.6-17.8%. The stabilizing effect of freely rotating guide vanes increases with increasing runner speed so that the range of stable operation is also extended upward. Figures 4; tables 1; references 4: 3 Russian, 1 Western.

[193-2415]

OPTIMAL PROFILING OF BLADE ARRAYS FOR WATER TURBINES

Minsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ENERGETIKA in Russian No 2, Feb 85 (manuscript received 27 Jun 83) pp 106-110

KAZACHKOV, L.Ya., candidate of technical sciences, NIKOLSKAYA, S.B., candidate of physio-mathematical sciences, and FEDOROV, A.V., candidate of physio-mathematical sciences, Leningrad Institute of Structural Engineering

[Abstract] The hydrodynamic design of blade arrays for water turbines is considered, by a method which yields the required performance characteristics with minimum energy losses under conditions of no cavitation and no separation. Such a design is based on a flow of water through a channel of variable width between neighboring blades, taking into account singularities near the edges. A specific design problem is optimizing the function $rv_u(s)$, namely the moment of the mean circumferential velocity (r - radius of blade curvature, v_u - circumferential component of absolute blade velocity averaged over the angular coordinate, s - length of arc of blade profile on meridional projection of latter) for minimum loss of enthalpy at pressures not exceeding the cavitation level and at values of the Reynolds number not exceeding the separation level. Such a problem is formulated as a variational one which can be solved by direct methods of variational calculus and as a problem of streamlining which can be solved by the method of conformal mapping for an axisymmetric surface. The procedure and results are demonstrated numerically on a peripheral array of adjustable buckets for a PL-40 water turbines. Article was presented by Department of Higher Mathematics. Figures 2; references: 5 Russian.
[169-2415]

SYSTEMATIZATION OF BASIC PARAMETERS CHARACTERIZING BLADED HYDRAULIC MACHINES

Minsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ENERGETIKA in Russian No 2,
Feb 85 (manuscript received 28 Sep 83) pp 100-106

GRYANKO, L.P., candidate of technical sciences, docent, and PYLEV, I.M.,
candidate of technical sciences, "Order of Lenin" Leningrad Polytechnic
Institute imeni M.I. Kalinin

[Abstract] A systematic overview is given of design and performance parameters pertaining to hydraulic machines with blades. These parameters include all relevant geometrical dimensions and energy characteristics of the five basic machine components: involute chamber - housing - guide vanes - runner with blades - draft tube. The parameters are normalized and defined, with optimum design and optimum performance as a reference. Theoretical relations describing the dependence of performance characteristics on design characteristics for turbines and for pumps, the two types of such hydraulic machines, are adjusted to fit statistically processed experimental data in each case. Article was presented by Department of Hydraulic Machinery Design. Figures 3; references 6: 4 Russian, 2 Western (1 in Russian translation).
[169-2415]

THERMOMECHANICAL STRESSES IN STRUCTURAL COMPONENTS OF TVV-200-2 TURBOGENERATOR STATOR

Moscow ELEKTRICHESKIYE STANTSII in Russian No 12, Dec 84 pp 30-33

PIKULSKIY, V.A., candidate of technical sciences, PODOLSKIY, V.V., engineer,
RYABOV, Ye.V., candidate of technical sciences, TSVETKOV, A.A., doctor of
technical sciences, and CHISTIKOV, A.A., engineer, All-Union Scientific
Research Institute of Power Engineering

[Abstract] The thermomechanical stresses in the stator of a TVV-200-2 turbo-generator are evaluated on the basis of a special mathematical model for analysis of the results of an experimental study. In this model the axial force and displacement profiles through the stator components, including copper and iron parts as well as the insulation materials, are described by corresponding first-order differential equations with stiffness and thermal expansivity as constant coefficients and with the elastic-frictional coupling between coils and teeth, a function of the axial coordinate, as a variable coefficient. The heating of all components is assumed to be uniform over their lengths and circumferences. Symmetry of the structure is assumed not only with respect to the shaft but also with respect to the center plane perpendicular to the shaft. The measurements were made with resistance strain gauges and copper-constantan thermocouples. The stator was tested under

operating conditions of start-up, full-load run, slow load change, fast load change, and an unload-stop-cooldown sequence, also with the stator coils heated with hot distilled water during a routine overhaul. The test conditions and the data have been correlated with known critical temperature rises and critical stresses. The results indicate an adequate margin of mechanical strength, even under the most severe conditions of fast load change. Figures 1; tables 2; references 9: 8 Russian, 1 Western.
[176-2415]

UDC 621.316.925:621.313.322-81

PERFORMANCE OF PROTECTIVE RELAYING SYSTEM FOR 50 MW TURBOGENERATOR DURING STARTUP BY FREQUENCY METHOD THROUGH THYRISTORS

Moscow ELEKTRICHESKIYE STANTSII in Russian No 12, Dec 84 pp 48-51

KUZHEKOV, S.L., candidate of technical sciences, MINAKOV, V.F., engineer, NEGRIMOVSKIY, P.Ya., engineer, SHIKHKERIMOV, I.A., engineer, SHTITELMAN, A.D., engineer, and SAMSONOV, N.I., engineer, Novocherkassk Polytechnical Institute, Rostov Department of All-Union Design, Surveying and Scientific Research Institute of Atomic Thermoelectric Power Projects, and Rostov Regional Administration of Power System Management

[Abstract] The startup of large synchronous generators driven by gas turbines with or without air storage and of large compensating synchronous motors by the frequency sliding method through thyristors is analyzed, both theoretically and on the basis of experience in the 50 MW Nesvetay GRES, from the standpoint of necessary protective relaying. Both the sensitivity and the selectivity of a differential protective system including saturable transformers with RNT and DZT relays as well as filters are evaluated on the basis of corresponding relations in circuit theory and on the basis of oscillograms. The response to zero-sequence voltage components at the neutral is considered as a method of protection against a short of the stator winding to ground, with the effect of nonsinusoidality of voltage and current waveforms with ripple content on the relay response being taken into account. Oscillograms of line and unbalance currents and of neutral-to-ground and zero-sequence voltages, taken throughout the starting period at frequencies 0, 15.6 Hz, and near synchronous speed upon inverter pull-in to natural commutation, indicate that the existing protection is inadequate. With the generator shaft under no load in addition to the exciter, a DZT-11 relay does not trigger sparsiously during startup by frequency sliding but is not sufficiently sensitive to internal and interphase shorts during the initial stage. While peak-voltage relays are not sufficiently selective, ZZG-11 and ZZG-12 relays are not sufficiently sensitive during the initial stage and must be tuned out during triple-voltage beats near pull-in. Figures 4; references: 6 Russian.
[176-2415]

AERODYNAMIC DESIGN OF HIGH-PRESSURE STAGES FOR STATIONARY GAS TURBINES

Moscow ENERGOMASHINOSTROYENIYE in Russian No 2, Feb 85 pp 2-3

KIRILLOV, I.I., doctor of technical sciences, LAPSHIN, K.L., candidate of technical sciences, SALIVON, N.D., candidate of technical sciences, and CHERNIKOV, V.A., candidate of technical sciences

[Abstract] Principles of aerodynamic design were applied to the high-pressure stages of new stationary gas turbines, on the basis of a mathematical model which includes the effects of vane and blade cooling. The most economical and efficient version was sought by the method of nonlinear optimization. The calculations were programmed in PL/1 for YeS computers. Models scaled down by 1:3.418, with guide vanes and runner blades conforming to these principles with the gas stream whirled so as to nearly satisfy the conditions $c_u r = \text{const}$ (c_u - circulation, r - radial coordinate), were built and then tested in the Laboratory of Turbine Construction Problems at the Leningrad Polytechnic Institute. They were tested at three pressure ratios $p_2/p_0^* = 0.418, 0.601, 0.808$ and over a wide range of the velocity coefficient $u_2/\sqrt{2h_0}$ (p_2 - exit pressure, p_0^* - stagnation pressure, u_2 - peripheral outlet velocity, h_0 - available isentropic enthalpy across the stage). The nominal design values of these parameters were 0.418 and 0.487, respectively. Figures 3; references: 5 Russian.
[193-2415]

DEPENDENCE OF EFFICIENCY OF GAS TURBINE STAGE ON MERIDIONAL EXPANSION ANGLE

Moscow ENERGOMASHINOSTROYENIYE in Russian No 2, Feb 85 pp 4-7

LASENKO, K.M., candidate of technical sciences, ROSKOSHNYI, N.V., engineer, SARANTSEV, K.B., engineer, and SHAYDAK, B.P., engineer

[Abstract] For the purpose of optimizing the performance of a gas-turbine stage by design, the dependence of its efficiency on the diffuser expansion angle is evaluated over the practical $0-31^\circ$ range of that angle. A series of 16 designs were tested, 11 with and 5 without whirler blades before the diffuser entrance, with a 6° or 14° shroud bevel angle or no bevel, at an air velocity within the $N_M = 0.3-0.35$ range of the Mach number and with flow conditions corresponding to the $N_R = (3-3.5) \cdot 10^5$ range of the Reynolds number. The stage efficiency was measured as a function of the normalized peripheral inlet velocity, the comparative data indicating the effect of losses at the whirler blades on the overall energy balance. These data are analyzed, and the stage economy is evaluated on the basis of applicable thermodynamic and aerodynamic relations. The analysis reveals that increasing the diffuser expansion angle increases the losses; there is a minimum loss for each angle.

This minimum loss does not ensure a minimum decrease in efficiency relative to that of a cylindrical channel, however, because the efficiency depends also largely on the bypassed fraction of the input energy. Figures 4; references: 10 Russian.
[193-2415]

UDC 627.824.141.1

OPTIMIZATION OF TURBINE OPERATING MODES IN CHARVAK HYDROELECTRIC POWER PLANT

Moscow ENERGOMASHINOSTROYENIYE in Russian No 2, Feb 85 pp 27-30

IVANCHENKO, I.P., candidate of technical sciences, and POTEKIN, A.A., engineer

[Abstract] The turbines installed and operating in the Charvak GES are of the RO-638a axial-radial type with a nominal power rating of 155 MW at 187.5 rpm under a 118 m head. The runner, 4.1 m in diameter, has 15 buckets, and there are 24 guide vanes. Since the startup of the first unit in December 1970, these turbines have been operating under various conditions with two significant increases of head and load from partial to full level in 1975 and again in 1978. Their power and cavitation characteristics as well as the strength characteristics of blades and vibration characteristics of bearings were recently studied in a series of commercial tests and on the basis of performance data, for the purpose of optimizing their operation under a steadily increasing demand. Power and head measurements yielded a load capacity of 170 MW under a head of 125-150 m with a 0.9% of efficiency as a feasible expectation. Cavitation measurements over the 75-140 m head range yielded a narrow peak reaching 140 W/(cm²·cm) within the 117-140 m head range almost regardless of speed. Stress measurements, with strain gauges accurate within 5 MPa, yielded a maximum stress of 86 MPa at the 150 MW power level. Vibration measurements over the 90-140 m head range revealed low-frequency radial modes in turbulence, peaking within the 60-70 MW power range and 25-30 MW below the laminar range with vibrations at runner-speed frequency only. Figures 4; references: 3 Russian.
[193-2415]

THERMAL STATE OF FITTINGS FOR STEAM ADMISSION TO HIGH-PRESSURE CYLINDER OF K-800-240-3 TURBINES

Moscow ENERGOMASHINOSTROYENIYE in Russian No 2, Feb 85 pp 30-32

AVRUTSKIY, G.D., candidate of technical sciences, NAKHIMOV, V.I., engineer, SKOPYLATOV, V.A., engineer, and TIKHOMIROV, S.A., engineer

[Abstract] The performance of the new steam admission fittings for the high-pressure cylinder, the third design modification of model K-800-240 turbines with the valve seat made of EI723 steel and the valve stem made of 15CrMo-FL steel, was evaluated in a study of their heating-cooling characteristics and thermal state during an operating cycle. According to the data, thermal stresses can be calculated on the basis of temperature differences ΔT range from +100 to -100°C between valve seat and valve stem, from +62 to -45°C between nozzle spout and nozzle housing, from +90 to -85°C between nozzle housing and inner cylinder housing. Figures 3; tables 1; references:

3 Russian.

[193-2415]

SCIENTIFIC-TECHNICAL PROBLEMS IN CONSTRUCTION AND OPERATION OF STEAM TURBINES

Moscow TEPLOENERGETIKA in Russian No 12, Dec 84 pp 2-10

TROYANOVSKIY, B.M., doctor of technical sciences, Moscow Institute of Power Engineering

[Abstract] Production of steam turbines in the USSR is now meeting all the demand by the power generating industry, including thermal electric condenser power plants run on fossil fuel, heat and electric power plants, nuclear power plants, and recently built nuclear heat and power plants. Outstanding and unique features of Soviet-made steam turbines with power ratings up to 1000 MW are an integrally forged runner without a center bore for the low-pressure cylinder in high-speed turbines operating with saturated steam (K-500/750 MW - 65 - 3000 rpm produced at the Kharkov Turbogenerator Manufacturing Plant and K-1000 MW - 65 - 3000 rpm produced at the Leningrad Metal Works with four low-pressure cylinders each; turbines with only up to three low-pressure cylinders are produced everywhere else in the world), power regulation by means of pressure sliding, aerodynamically shaped blades for specific ranges of the Mach number (typically $N_M = 1.8-2.2$), retention of original clearances for steam passage during entire operating period and after overhauls, and effective intra-turbine separation of water from steam. Evidence of the high level of Soviet turbine production is the wide diversity of design variants for specific applications and many foreign (CEMA) customers. A survey of design and performance data reveals that, while turbines

everywhere are now built to operate with live steam at 565-580°C or higher temperatures, Soviet-made turbines are built for lower temperatures of the cooling water and correspondingly deeper vacuum than turbines built in other countries, specifically in the United States. This results in higher efficiency but complicates the design, construction, and operation of large units. The two major problems of turbine operation are, of course, reliability and economy. Reliability has improved tremendously, with typically only 0.5% of all shutdowns in nuclear power plants in the USSR being necessitated by failures and even that figure being higher than for USA and FRG nuclear power plants. The major causes of failure are still stress corrosion, vibration, bearing defects and, in the case of operation with wet steam, also secondary breakdown of the first high-pressure stages. Further improvements in turbine economy, as well as turbine efficiency, still depend specifically on perfection of aerodynamic blade shaping and optimum pressure staging, but generally on improvement of the design methods with accurate feedback of test data. Since both reliability and economy are limited by the weakest components in a system, their identification and correction are most important. Particularly vulnerable here are feedwater pumps and separator-superheater elements. This survey of the state of the art does not delve into automation and maneuverability of automatic control, nor into the technology of turbine manufacture and into problems of repair and overhaul. Tables 4; references 47: 30 Russian, 17 Western.
[174-2415]

UDC 621.165

K-220-130/3600 STEAM TURBINE

Moscow TEPLONERGETIKA in Russian No 12, Dec 84 pp 16-19

ZINCHENKO, A.N., engineer, Design Department of [expansion unknown] Turbines, Kharkov Turbine Manufacturing Plant

[Abstract] The K-220-130/3600 condenser-type steam turbine with an intermediate superheating stage and a maximum continuous-duty power rating of 222 MW at 3600 rpm is designed for operating with subcritical steam at a 670 t/h rate from a drum-type boiler and for driving a 3-phase 60 Hz generator in the Republic of Cuba's power system. It combines reliable operation with compact structure and has been designed for simple disassembly, transport, and assembly. The basic 2-cylinder structure consists of 6+6 stages in the high/medium-pressure part and 2x4 stages in the low-pressure part. The runner of the high/medium-pressure part is integrally forged with a center bore, made of 20CrZMoVFA steel. The runner of the low-pressure part is welded, made of 20CrNi2MoFA steel. The condenser has a symmetric structure, with double-pass double-flow of cooling water and with suction of the steam-air mixture at the center. The turbine is equipped with a complete lubrication system including dashpots and standby pump, a speed regulator-equalizer, an electrohydraulic power regulator, and an independent protective relaying system. The turbine is both technically and economically competitive on the foreign market. Figures 1; tables 1.
[174-2415]

DEPENDENCE OF NATURAL VIBRATION FREQUENCIES OF TURBINE RUNNER BLADES ON COMPLIANCE OF THEIR MOUNT

Moscow TEPLOENERGETIKA in Russian No 12, Dec 84 pp 33-36

BORISHANSKIY, K.N., candidate of technical sciences, NAUMOV, A.V., candidate of technical sciences, and SHILOVA, Ye.V., engineer, Turbine Design Department, Leningrad Metal Works

[Abstract] The compound flexural and torsional vibrations of turbine runner blades are analyzed, for the purpose of determining the dependence of their natural frequencies on the compliance of the blade mount. The calculations are based on the corresponding system of three differential equations for a concave-convex blade with the centers of gravity of all cross-sections lying on one straight radial line, with appropriate integral expressions for the moments of inertia and with the St.Venant twist function included as well as the moduli of elasticity and shear. The blade cross-sections are subdivided into elementary rectangles for integration, whereupon the fundamental frequency and the second-harmonic frequency are calculated with and without the mount compliance taken into account. Calculations were made for six different blades with differently proportioned profiles, namely blades in high-pressure, medium-pressure, and low-pressure stages of K-800-240-5 and K-1200-240-3 turbines, respectively. The analysis results reveal that compliance coefficients $c_{11}^{x,y}, c_{12}^{x,y}$ are almost equal to those for a beam with rectangular cross-section, and compliance coefficients c_{22}^x, c_{22}^y do not depend significantly on the distribution of normal stresses in the blade root section (x, y -principal axes of coordinates through the center of gravity in the plane of the cross-section). Numerical results covering the 25-2200 Hz range reveal that taking the mount compliance into account reduces the calculated frequency by an amount which increases with increasing blade "stiffness" but decreases with an increasing ratio of blade length to gyration radius of the blade root section. The natural deflection modes were also determined, for the typical $D_m/l=5.45$ ratio of mean blade array diameter to blade length. In all cases the frequencies calculated were higher than the frequencies measured. Figures 4; tables 1; references: 4 Russian. [174-2415]

NAVIGATION AND GUIDANCE SYSTEMS

FLEET TRAINING CENTER TO GET SUBMARINE MISSILE SIMULATION

Moscow KRASNAYA ZVEZDA, 23 May 85 p 1

POPOV, N., Captain 3rd Rank (Baltic Fleet)

[Text] Submarine crewmen will see quite a few innovations at their training center during the summer period of training.

Special attention has been devoted to adjustment and regulating work on a simulator of the use of missile weapons. This work is being done by Captain 3rd Rank N. Katantsev and his helpers. There has long been a need for such a simulator. Previously seamen took lessons in certain types of missile training directly on board submarines. The innovation not only will make it possible for personnel of missile battle units to practice at the training center, but also for ship battle units to work out approaches to a missile attack.

FTD/SNAP

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CSO: 1861/282

PERIODIC MOTION OF SATELLITE RELATIVE TO CENTER OF MASS WITH UNIAXIAL ORIENTATION IN GRAVITATIONAL FIELD

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKhanika TVERDOGO TELA in Russian No 1, Jan-Feb 85 (manuscript received 28 Apr 83) pp 3-13

SAZONOV, V.V. and SIDORYUK, M.Ye., Moscow

[Abstract] The motion of a solid in a circular orbit relative to the center of mass is considered, with such a motion characterizing that of a satellite driven by the moment of the gravity forces. The problem is formulated in two Cartesian systems of coordinates with a common origin, an inertial one and an orbital one. The motion is described by a system of three first-order differential equations for the derivatives of the angular velocity components with respect to dimensionless time. The orientation of the inertial system relative to the orbital one is described by three trigonometric relations for the derivatives of angles with respect to dimensionless time. The three "triangle inequalities" $A + B - C$, $B + C - A$, $C + A - B$ for the three moments of inertia A, B, C of the satellite yield the general physically possible ranges of $\mu = (B - C)/A$ from -1 to $+1$ and $\lambda = A/C$ from 0 to $2/(1 - \mu)$. Here the periodic solutions to the system of equations are sought for $\lambda \ll 1$, as extensions of the "generating" solutions for $\lambda = 0$ (degeneracy of a three-dimensional body into a thin bar). The existence of periodic solutions for this case is provable by the Poincare method, and their orbital stability, which depends on the roots of the characteristic equation, can be analyzed by the method of variations. The analytical part of solving this boundary-value problem, with a change of variables from relative to absolute velocity components and taking into account the symmetry of the system, is followed by a numerical part. The latter yields not only families of generating solutions for $\lambda = 0$ and their extensions to $\lambda = 0.1$ or farther, but also two families of Lyapunov solutions. Some solutions correspond to periodic oscillation or rotation about the axis of the smallest moment of inertia, others are almost periodic ones. The authors thank V.A. Sarychev for helpful discussions. Figures 5; references 8: 5 Russian, 3 Western (1 in Russian translation). [189-2415]

MOTION OF SATELLITE RELATIVE TO CENTER OF MASS CAUSED BY MOMENTS OF LIGHT-PRESSURE FORCES

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian No 1, Jan-Feb 85 (manuscript received 31 May 83) pp 14-21

LESHCHENKO, D.D., Odessa, and SHAMAYEV, A.S., Moscow

[Abstract] The motion of a satellite relative to a center of mass is analyzed for the case of such motion caused by moments of light-pressure forces. The problem is formulated in three right-hand Cartesian systems of coordinates with a common origin at the center of inertia of this satellite; the latter is assumed to be a solid of revolution and its orbit assumed to be elliptical. The corresponding equations of perturbed motion, with three Euler angles and two angles of the angular momentum vector as variables, contain the force function of light pressure in the form of a coefficient α_1 which depends only on the angle ξ_s between the radius-vector of the orbit and the axis of symmetry. For simplification, the light-pressure coefficient is expanded into a power series in the cosine of this angle. Two special cases are subsequently considered, namely $\alpha_1 = \alpha_{10}$ (constant term of series) and $\alpha_1 = \alpha_{11} \cos \xi_s$ (first-power term of series). For convenience, the kinetic energy of the satellite can replace the Euler angle between its angular momentum vector and the radius-vector of its orbit as a variable, the kinetic energy being a function of this and one other Euler angle. The problem is solved upon introduction of three small parameters $\alpha_{10} \sim \varepsilon \ll 1$, $\alpha_{11} \sim \varepsilon$, $\omega_0 \sim \varepsilon$ (ω_0 - mean angular velocity of the center of mass along the orbit), whereupon the solution is analyzed over a long time interval $t \sim \varepsilon^{-1}$. One constant in the problem is the light pressure at the earth $p_0 = E_0/c = 4.72 \cdot 10^{-6} \frac{\text{t}}{\text{A}}$ (t - time, A - surface area, R_0 - radius of earth's orbit, $E_0 = 1200 \text{ kcal} \cdot \text{h}/\text{m}^2$ - energy flux at distance R_0 from center of the sun). The authors thank F.L. Chernousko, V.V. Belëtskiy and L.D. Akulenko for formulation of the problem and helpful discussions. Figures 2; references 8: 7 Russian, 1 Western (in Russian translation). [189-2415]

DYNAMICS OF ORIENTING AND STABILIZING SYSTEMS FOR SPACECRAFT WITH CONTROLLABLE GRAVITATIONAL STABILIZER

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian No 1, Jan-Feb 85 (manuscript received 1 Mar 83) pp 22-30

POTAPENKO, Ye.M., Zaporozhye

[Abstract] The problem of spacecraft orientation and stabilization is solved by analysis of the servomechanism dynamics, taking into account both

the elasticity and the thermal deflection of the gravitational stabilizer rod. The auxiliary servomechanism components considered are a pitch-roll-yaw set of three flywheels, or a "V - pitch" set of two 2-stage gyroscopes with a pitch flywheel, or three pairs of jet engines with adjustable average thrust of each and a power yaw gyroscope, or an orthogonal set of three electromagnets with one power gyroscope. The corresponding general system of equations of motion is solved, assuming known angles and angular velocities. The control moments are stipulated so as to simplify the control law and minimize parasitic moments acting on the spacecraft. Relations are obtained and curves are plotted describing the servomechanism response in the time domain, also the dependence of both control moment and gravitational moment on the stability parameter $\eta^* = \eta/\omega_0$ (η - modulus of the negative roots of two characteristic equations, a cubic one for the pitch and a quartic one for the yaw, all these roots assumed to be equal; ω_0 - modulus of the orbital angular velocity) in the $\eta < 8\omega_0$ range where instability could occur. The maximum control moment is found to be comparable to and almost equal to the gravitational moment, which relaxes the size, mass, and energy constraints on the auxiliary servomechanism components for pitch and roll control. Figures 4; references 6: 2 Russian, 4 Western (3 in Russian translation). [189-2415]

UDC 531.55:521.2

CORRECTION OF 'SPACE TACHOMETER - STABILIZING GYRO' SYSTEM

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian
No 1, Jan-Feb 85 (manuscript received 9 Nov 83) pp 31-36

TKACHENKO, A.I., Kiev

[Abstract] The problem of orienting and stabilizing a tachometer mounted on a moving spacecraft is solved, with readings of angular coordinates which describe the position of the orthonormalized vector basis $E(e_1, e_2, e_3)$ moving rigidly with the spacecraft. The latter, assumed to be nondeformable, carries a gyroscope for stabilizing the position of the inertial vector basis $I(i_1, i_2, i_3)$ in space and for measuring the Euler angles which characterize the orientation of this I-basis relative to the J-basis which is also rigidly tied to the spacecraft. The orientation of the E-basis and the J-basis relative to one another is known in the first approximation only. The necessary correction of the "tachometer - gyro" system is made, taking into consideration the proximity of the E-basis to the slowly moving orthonormalized K-basis and of the I-basis to the L-basis. The problem is analyzed in quaternions and ranks. The condition for its solvability is established, whereupon the error of estimates and corrections is evaluated on the basis of quantized readings. It is found possible to make this error approach the error which results when the readings are not quantized. References 8: 5 Russian, 3 Western (1 in Russian translation). [189-2415]

UDC 539.3.534.1

HARMONIC VIBRATIONS OF VISCOELASTIC SHELLS OF PIEZOCERAMIC MATERIAL WITH ATTENDANT HEATING

Kiev PRIKLADNAYA MEKhanika in Russian Vol 21, No 2, Feb 85 (manuscript received 27 Dec 83) pp 60-67

KARNAUKHOV, V.G. and KIRICHOK, I.F., Institute of Mechanics, UkSSR Academy of Sciences, Kiev

[Abstract] A thermomechanical theory on the basis of Kirchhoff-Love hypotheses is constructed for vibrations of thin ceramic shells in piezoelectric transducers, considering that the material is viscoelastic and its properties are temperature-dependent. The equations of state and of motion are derived from three-dimensional equations of electroelasticity with mechanical intensity as independent variables. The resulting system is one of coupled equations which thus takes into account the interaction of mechanical, thermal, and electric fields. Axisymmetric radial vibrations of normally polarized infinitely long cylindrical shells and closed spherical shells are typical examples for which these equations are readily solvable. Accordingly, numerical results are shown for a spherical shell of PZT-4 ceramic material with vacuum inside and water outside. Figures 2; references 7: 6 Russian, 1 Western (in Russian translation).
[190-2415]

UDC 624.074.4.04

APPROACH TO TACKLING PROBLEMS OF WRINKLED STATE OF SOFT SHELLS

Kiev PRIKLADNAYA MEKhanika in Russian Vol 21, No 2, Feb 85 (manuscript received 20 Jun 83) pp 67-73

KALININ, V.S. and MELAMUD, A.S., Leningrad Institute of Ship Construction

[Abstract] A new approach is proposed for solving problems of the wrinkled state for soft shells, namely treating a wrinkled shell as a smooth biaxial one in the zero-moment state. This eliminates the need to first determine

the directions of wrinkles. Instead, the length of an arc element of any curve on the shell surface is defined as the distance between two points in three-dimensional space, this distance being sufficiently small before deformation to allow replacing the arc with a straight line segment but also sufficiently large so as not to depend on the locations of the two points on each wrinkle. This distance is then, in a sufficiently high order of precision, proportional to the differential of the corresponding Lagrange coordinate. The relation between internal forces and global strains, the latter representing changes in the surface metrics and ignoring local effects, is established accordingly on the basis of negligible compressive stresses in the real shell after stability loss and negligible normal stresses along the wrinkles. An isotropic shell material is considered first, in which case global and local strains along the wrinkles become the same. The resulting relations between corresponding stress tensor and strain tensor components can, however, also be used as the first approximation for an only slightly deformable anisotropic shell material. Figures 5; references: 8 Russian.
[190-2415]

UDC 624.074

EXPERIMENTAL STUDY OF TRIPLE-LAYER SPHERICAL SHELLS UNDER NONUNIFORM PRESSURE

Kiev PRIKLADNAYA MEKhanika in Russian Vol 21, No 2, Feb 85 (manuscript received 10 Apr 83) pp 117-119

KOTELNIKOV, V.U. and TARASENKO, V.G., Rostov Higher School of Military Ordnance Engineering imeni M.I. Nedelin

[Abstract] An experimental study of hemispherical shells consisting of three variable-thickness layers was made, its purpose being to determine their behavior under nonuniform external pressure. The two outer sheath layers were made of AMTs-M aluminum alloy, with a filler (modulus of elasticity $E = 0.73 \cdot 10^4$ MPa, modulus of rigidity $G = 14.3$ MPa) between them and with a metal flange $13.7 \times 50 \text{ mm}^2$ in the cross-section around the bottom base edge. Two batches of 10 shells were tested; in the first batch both sheaths 1.5 mm thick at the vertex and in the second batch the inside sheath 1.5 mm thick but the outside sheath 2.0 mm thick at the vertex. All shells had an inside diameter of 400 mm and a 14 mm thick filler. The tests were performed in an array of six annular chambers with elastic walls, all six wrapped with a common jacket so as to prevent tangential motion and each inflatable to a different pressure. Measurements were made with PKB resistive strain gauges on a 10 mm base and readings were recorded with a TsTM-3 digital bridge instrument. The results indicate higher stresses and larger strains in the sheath directly under the pressure load. The results of this study should be useful for devising theoretical methods of designing triple-layer spherical shells. Figures 3; tables 1; references: 1 Russian.
[190-2415]

INDUCED VIBRATIONS OF SPHERICAL SHELL IN ACOUSTIC WEDGE

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 21, No 2, Feb 85 (manuscript received 13 Jan 84) pp 53-60

POTAPOV, M.A., Kiev

[Abstract] A spherical shell of an elastic and isotropic material with a concentric solid vibrating sphere inside is placed between two plane walls intersecting so as to form a wedge. The acoustic field in such a wedge is described by two Helmholtz equations for the regions inside and outside the shell, respectively, supplemented with three equations of motion for the shell. Boundary conditions are stipulated at the surface of the wave-emitting sphere, at the median surface of the shell as the interface between the two regions, and at the wedge walls. The two media inside and outside the shell are characterized by the products of their respective density and acoustic velocity. The problem of shell vibrations is solved by the method of virtual images with the wedge angle $\alpha = \pi/q$ as discrete parameter ($q = 1, 2, \dots$). With the solution sought in the form of a series with spherical Bessel functions and associated Legendre polynomials, an infinite system of linear algebraic equations is obtained which has a normal determinant and an upper bound is obtained which converges. This system of equations is quasi-regular, solvable by the method of reductions, and the series can be evaluated asymptotically. Numerical results have been obtained for a steel shell with a vibrator and between perfectly rigid walls of a wedge. Figures 3; references: 5 Russian.
[190-2415]

CERTAIN RELATIONS FOR SYSTEMS WITH DRY FRICTION

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 280, No 1, Jan 85 (manuscript received 14 Jun 83) pp 52-56

LEVITAS, V.I., Institute of Superhard Materials, UkSSR Academy of Sciences, Kiev

[Abstract] A definition of friction force is proposed, which is more precise than merely in terms of positive power and from which an associated law of friction corresponding to the orthogonality principle in the theory of plasticity will follow as corollary. This definition is based on the Lagrange

equations of motion $-I \stackrel{\text{def}}{=} \frac{d}{dt} \frac{\partial T}{\partial \dot{q}} - \frac{\partial T}{\partial q} = Q - X$ (q, \dot{q} - generalized coordinates,

I - vector of inertia forces, X - vector of dissipation forces, Q - vector of active forces, $T(q, \dot{q})$ - kinetic energy, t - time) for a system with stationary holonomic couplings, with m degrees of freedom, and with dry friction. The

conventional definition is accordingly supplemented with the postulate of dissipation and constraints on the $X(\dot{q})$ function. With this extended definition, the laws of mechanics yield not only associated laws of friction but also extremum principles in the force space and in the velocity space as well as a corollary of these principles that the surface of the dissipation function $D(\dot{q}) = X(\dot{q}) \cdot \dot{q}$ is nonconcave. Accelerated pullout from equilibrium is interpreted from this standpoint, and two relevant theorems for systems with dry friction are proved. The first theorem pertains to the uniqueness of the solution to the problem of dynamics. The second theorem pertains to the relations $(Q_1 - Q_2) \cdot (\dot{q}_1 - \dot{q}_2) \geq 0$ between two different forces $Q_1(\dot{q}_1), Q_2(\dot{q}_2)$ pulling a system out of equilibrium. Article was presented by Academician A.Yu. Ishlinskiy on 14 April 1983. Figures 1; references: 7 Russian. [155-2415]

UDC 539.3

ENERGY CRITERION OF DYNAMIC SNAP-OVER FOR ELASTIC SPHERICAL SHELLS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 280, No 1, Jan 85 (manuscript received 16 Jul 83) pp 60-63

SRUBSHCHIK, L.S., Rostov State University imeni M.A. Suslov, Rostov-na-Donu

[Abstract] An energy criterion is proposed for estimating the critical snap-over load on spherical shells under any of the basic boundary constraints. This astatic critical load is, accordingly, the minimum load under which transition from ground equilibrium to unstable supercritical equilibrium with a potential energy equal to that before snapping can occur. The dimensionless classical two differential equations for radial force and deflection are formulated specifically for thin shells under external pressure, with boundary constraints of a free support, rigid clamp, fixed hinge, or movable hinge. The energy integral which satisfies the transient solution to this system of equations contains a functional $J(w, p)$ of deflection and pressure, with respect to which first the critical load and then the critical momentum are defined. The critical parameters have been evaluated numerically for various values of the shell parameter $\Lambda = 2 \cdot 3(1-\nu^2)^{1/2} (H/h)^{1/2}$ (ν - Poisson ratio of the shell material, H - lift height, h - wall thickness) on which they depend, assuming $\nu = 1/3$ and using the method of boundary layer for the asymptotic case of $\Lambda \rightarrow \infty$. The author thanks V.I. Yudovich for helpful discussions. Article was presented by Academician A.Yu. Ishlinskiy on 15 July 1983. Tables 1; references 15: 7 Russian, 8 Western. [155-2415]

WIDE-ANGLE INSTRUMENT FOR MEASURING DIVERGENCE OF LASER BEAM

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 84 (manuscript received 29 Nov 83) p 240

POKROVSKIY, Yu.A., MAKARETSKIY, Ye.A. and KHURKHULU, Yu.S., Chair of Radioelectronics, Tula Polytechnic Institute

[Abstract] An instrument for measuring the divergence of laser beams and displaying the power distribution over the beam cross-section is now available, its main features being small size and fast measurement. It consists of a goniometric resonance filter-analyzer and a deflecting mirror. The filter is made of two glass prisms separated by an air gap between their diagonal facets. The dependence of its transmission coefficient on the angle of radiation incidence is analogous to the resonance characteristics of an electric LC-circuit. The angle range, analogous to the frequency band of an electric filter, is $5 \cdot 10^{-5}$ - $2 \cdot 10^{-2}$ rad, with a resolution of up to $2.5 \cdot 10^{-5}$ rad. The deflecting mirror serves as means of varying the incidence angle, and thus also the transmitted radiation power proportionally to its angular distribution. The latter is displayed on the screen of a cathode-ray oscillograph by a signal from the photoreceiver behind the angle filter. With the oscillograph are included a sawtooth-voltage generator for calibrating an optical input attenuator before the deflector and a generator of scale markers for monitoring the deflector position. The instrument can handle laser beams with a diameter of up to 50 mm and a radiation power of up to 50 W. A set of interchangeable analyzer prisms is available for covering the 0.44-1.15 μm range of radiation wavelengths. The size of the instrument is 340x115x80 mm^3 (weight 20 kg), the size of the display module is 410x230x160 mm^3 (weight less than 8 kg). Figures 1.
[107-2415]

UDC 620.179.16

UNIVERSAL INSTRUMENT FOR ACOUSTIC INSPECTION

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 84 (manuscript received 30 Jan 84) p 242

NASHUK, Ye.G., BESHENTSEV, V.D. and ATAYEV, A.Sh., Chair of Solid-State Physics, Dagestan State University, Makhachkala

[Abstract] An instrument is now available for wide-range nondestructive inspection of materials and products by measurement of either the ultrasound velocity and absorption coefficient or the acoustic emission activity. The former are measured by the echo-pulse method; high resolution is attained by conversion to a time interval relative to selected zero-crossovers and subsequent discretization of that interval. Any of the first 16 echo pulses in

a pulse train can be delayed. The operating frequency range in this mode is 1-15 MHz, the time intervals between pulses are indicated on a 5-digit display with 100, 10, or 1 ns units of the last digit and with a resolution of up to ± 2 ns. The absorption coefficient is measured within 20% accuracy at the 100 m^{-1} level. Acoustic emission activity is measured, and indicated on a 3-digit display, after amplification of the signal by a low-noise extension preamplifier and truncation of its frequency spectrum by a filter array. The sensitivity is 5 μV and the passband is 60-400 kHz in this mode of operation. The instrument is $480 \times 120 \times 475 \text{ mm}^3$ large and weighs 10 kg, drawing 40 VA from a 220 V - 50 Hz power line. Figures 1.

[107-2415]

UDC 538.3.08:621.791.05.019

FIVE-CHANNEL INSTRUMENT FOR ACOUSTIC FLAW DETECTION BY METHOD OF ACOUSTIC EMISSION

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 84 (manuscript received 2 Jan 84) p 243

ALABICHEV, A.I., TYALIN, Yu.I., GOLOVIN, Yu.I., SLETKOV, A.A., USKOV, V.I., GLADYSHEV, S.A. and BYKOV, A.N., Chair of Theoretical Physics, Tambov State Pedagogical Institute

[Abstract] A five-channel instrument is now available for detecting and recording acoustic emission from defects which develop during welding, cooling, or under load. It contains a +12, -12, +24 V power supply, a control module for automatically regulating the number of acoustic emission pulses and their intensity, and five identical measuring channels. Each channel consists of a high-pass filter, an attenuator, a linear amplifier, and an intensity meter, also a piezo-electric transducer with an extension preamplifier. Each intensity meter includes two pulse counters with analog converters producing histograms of the pulse rate by alternating count and readout in successive cycles. Individual pulses can be extracted for display on the screen of an S8-9A storage oscilloscope. Included are also a KSP-4 automatic recording instrument and a ChZ-34 frequency meter. Each channel has a 20 μV sensitivity threshold at a 10 dB signal-to-noise ratio, a 90 dB gain with regulation over a 60 dB range, and a 300-2000 kHz frequency range. The counters have capacities of 10^2 , 10^3 , and 10^4 pulses with the count and storage time 3, 10, and 30 s, respectively. All components are built with semiconductor devices and integrated-circuit chips. The instrument is $530 \times 300 \times 200 \text{ mm}^3$ large and draws 90 W from a 220 V - 50 Hz power line. Figures 1.

[107-2415]

DIGITAL MONITOR FOR CRYOGENIC APPARATUS

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 84 (manuscript received 30 Jan 84) p 246

ORANSKIY, L.G., PAVLICHENKO, L.F. and KABDIN, N.N., Special Design-Engineering Office, Donetsk Institute of Engineering Physics, UkSSR Academy of Sciences, Donetsk-114

[Abstract] A digital monitor for cryogenic apparatus with superconducting magnet systems is now available. It measures the liquid-helium level in a cryostat with a transducer made of superconductor wire. It measures the temperature of a superconducting magnet system without a superconducting switch on the basis of the solenoid winding resistance. It removes excess liquid coolant from the cryostat by actuating a heater placed on the bottom, and it measures the temperature in the cryostat with a copper resistance-type transducer placed on the heater. It heats the solenoid to the required temperature by actuating a ladle with an evaporator which pours nitrogen. It fills and replenishes the nitrogen vessels by actuating the appropriate mechanism. The monitor contains a K572PV2 digital-to-analog converter with one output connected directly to an array of ALS342B light-emitting indicator diodes. Its temperature range is 10-340 K. Its two ranges of helium level reading with probes 200-700 mm long are 0-20% and 0-100% within 0.1% and 1% accuracy, respectively. The maximum evaporator power is 100 W. The monitor is 285x170x210 mm³ large and weighs 8.6 kg, drawing 160 VA from a 220 V - 50 Hz power line. Figures 1.
[107-2415]

UDC 535.568

MAGNETOOPTICAL APPARATUS WITH ROTATING POLAROID

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 84 (manuscript received 18 Jul 83) pp 157-158

GRISHANOV, V.N., Kuybyshev Institute of Pedagogy

[Abstract] A magneto-optical apparatus has been built with a rotating polaroid for measuring the angular displacement of the polarization plane. It consists of a 12 V - 30 W incandescent lamp as a light source, a UM-2 monochromator, a fixed dichroic polaroid, an electromagnet with the test specimen in the interpolar space and with a hole through each pole tapered toward the specimen for passage of light, a rotating dichroic polaroid, a dichroic analyzer with a goniometer, a theodolite, and an FEU-68 photomultiplier with an emitter follower. The electrical measuring instruments behind the emitter follower are two selective amplifiers in parallel, with a ratio meter between them on the output side, feeding signals to an analog voltmeter and to a digital voltmeter,

respectively. The apparatus is designed to operate at any wavelength within the 400-750 nm range. Both the rotation of the polarization plane by the test specimen and the transmission coefficient of its material are measured on the basis of a relation between these two parameters, the ratio of light intensity at the receiving photomultiplier surface to light intensity at the specimen surface, the angle between the analyzer and the fixed polaroid, and the speed of the rotating polaroid. The apparatus is used for study of Faraday's magnetooptic effect as well as of magnetization reversal processes in ferrite-spinel and garnet single-crystal films. Figures 2; references: 4 Russian. [107-2415]

UDC 621.373

SYNCHRONIZATION SYSTEM FOR PULSED POWER LASER WITH OPTOELECTRONIC CONTROL

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 84
(manuscript received 4 Jul 83) pp 163-168

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[Abstract] A synchronization channel has been built for pulsed power lasers with optoelectronic control. It consists of a transmitter and a receiver connected through a 5 m long fiber-optic cable, each in a separate shielded housing, and a high-voltage nanosecond pulse shaper followed by an electro-optic modulator behind the receiver. The transmitter contains a photodiode at the input on which synchronizing pulses impinge, a delay line followed by a shaper of current pulses consisting of an avalanche transistor with an emitter triggering circuit, and a semiconductor-type injection laser with reverse bias at the output. The avalanche transistor is triggered softly so as not to damage the laser diode, since emitter triggering is more stable and reliable than base triggering. The receiver contains an input photodiode and a 2-stage output amplifier; the latter has negative feedback in parallel and an emitter follower behind. The shaper of high-voltage nanosecond pulses includes an autonomous power supply and a kratron output commutator; the latter triggered by a 3-stage nanosecond pulse generator is designed to minimize and stabilize the time delay. The hardware between this commutator and the electrooptic modulator includes two transformers with toroidal ferrite cores, two shaping coaxial lines, and two nonlinear-inductance coils. The modulator consists of two electrooptical crystals, each with a separate analyzer spread in space for maximum depth and linearity of light intensity modulation as well as minimum active duration of optical pulses. The synchronizing channel was used for control of a transverse-excitation atmospheric-pressure CO₂-laser operating in the repeater mode. Figures 7; references 9: 6 Russian, 3 Western (1 in Russian translation). [107-2415]

SET FOR AUTOMATIC GATHERING AND RECORDING OF DIGITAL DATA

Moscow PRIBORY I TEKNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 84 (manuscript received 19 Dec 83) p 232

PIKULIK, V.V., BRESLAV-MASLENNIKOV, M.B., SUDAK, Yu.I., ANTOSHIN, A.A., SAMONOV, S.M. and SHIVKO, L.S., Institute of Solid-State and Semiconductor Physics, BSSR Academy of Sciences, Minsk.

[Abstract] A set for automatic gathering and recording of digital data from peripheral equipment, with the aid of an APM-3M printer and a PL-150 punch, is now available. It consists of a coupling module, a control and data output module, and a power supply. The coupling module and the power supply can operate alone, as a storage and multiplexer. The input register in the coupling module has a 320-bit memory. The set operates with a binary-decimal parallel code 1-2-4-8, 1-2-4-2, 1-2-4-2* or a binary-decimal sequential code 1-2-4-8 for the input data, with up to five data sources. The log "1" corresponds to $\pm(2.4-24)$ V and the log "0" corresponds to $0-(+0.6)$ V. Each module measures $600 \times 500 \times 225$ mm³ and weighs 60 kg. The set draws 100 VA from a 220 V -50 Hz power line. Figures 1.
[107-2415]

DEVICE FOR DATA EXCHANGE BETWEEN LOCAL INFORMATION AND CONTROL NETWORKS ON MICROCOMPUTER BASE

Moscow PRIBORY I TEKNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 84 (manuscript received 26 Dec 83) pp 232-233

SAVCHUK, V.L., PASHUK, V.F. and PATRAKHINA, O.V., Scientific Research Institute of Automation and Electromechanics at Tomsk Institute of Automatic Control Systems and Radioelectronics

[Abstract] A device for data exchange between local information-and-control networks using "Elektronika-60" microcomputers is now available, built with series 155 and 589 integrated microcircuits on a printed-circuit board. It operates in the start-stop programmed control mode. Data registers in the transmitter and in the receiver have correspondingly the same address, which ensures high speed. The user specifies an address by unsoldering appropriate jumpers on the board. The rate of data input to and output from the communication channel, a 75 ohm cable 1 km long matched at both ends, is 620 kbits/s. The device is energized from an "Elektronika-60" power supply, drawing not more than 1 A from a +5 V source. It measures $252 \times 143 \times 12$ mm³ and weighs 0.35 kg. Figures 1.
[107-2415]

INSTRUMENT WITH MICROPROCESSOR FOR MEASURING AMPLITUDES AND PHASE SHIFTS

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 84 (manuscript received 12 Dec 83) pp 234-235

PANKO, S.P., TKACH, V.I. and KOLPAKOV, Yu.V., Introscopy Laboratory, Krasnoyarsk Polytechnic Institute

[Abstract] An instrument with a microprocessor for measuring the amplitudes of signals and the phase shifts between signals is now available. It operates by the method of discrete-orthogonal data extraction from the signal channel and the reference channel. The instrument consists of an amplifier, a digital gain control, an integrator, a sample-storage, an analog-to-digital converter, a digital memory, and a computer with the microprocessor on series K588 integrated-circuit chips. Immunity against spectrally discrete noise is ensured by a weighting algorithm. The instrument operates at fixed signal frequency and can be tuned over a wide range (1-312 kHz) by means of a special converter. It can measure signal amplitudes ranging from 3 μ V to 300 mV, with a 5% error at 20 kHz, and the phase shift with an error of 0.3-5° depending on the amplitude. Measurements can be made in 0.1, 1, or 10 s. The instrument measures 300x250x250 mm³ and weighs 4 kg. It draws 4 W from the power supply.

[107-2415]

APPARATUS WITH TRANSPARENT ANVILS-WINDOWS FOR OPTICAL AND X-RAY ANALYSIS UNDER HIGH PRESSURE

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 84 (manuscript received 15 Aug 83) pp 174-178

FURSENKO, B.A. and KHOLDEYEV, O.V., Institute of Geology and Geophysics, Siberian Department, USSR Academy of Sciences, Novosibirsk, LITVIN, Yu.A. and KROPACHEV, V.D., Institute of Experimental Mineralogy, USSR Academy of Sciences, Chernogolovka

[Abstract] An apparatus for optical and x-ray analysis of minerals has been built consisting of a kinematic plunger mechanism and a force mechanism. The latter produces a force which moves the plunger with self-alignment through a long cylinder without loss of parallelism between the active surfaces. The force is produced by a power screw and a stack of disk springs under a displacement gage and is transmitted through a lever mechanism of the second kind consisting of a standing lever and a movable one. A metal gasket around a ruby-crystal pressure transducer between diamond or bromellite anvils at the tips of both levers is hinge-coupled to each. All three hinge axes being mutually orthogonal for maximum freedom of self-alignment for

the force mechanism. All pressure-bearing components are made of high-strength steel quenched to Rockwell C 35-55 hardness. A bayonet joint facilitates assembly and disassembly of both mechanisms. Optical measurements are made on the basis of the ruby R-line shift, using a He-Cd laser or a mercury-arc lamp, a scintillation microscope with illuminator and neon tube, supplemented with long-focus objective lenses from a polarization microscope, a monochromator with control module connected to the microscope through a fiber-optic cable, an FEU-79 photomultiplier, a compensation-type automatic recording instrument with an auxiliary rheostat, and an Endim XY-plotter. Polymorphic transformations at room temperature were recorded in AgI (0.24 and 0.29 GPa), RbCl (0.49 GPa), HgI₂ (1.3 GPa), KCl (2.0 GPa) using bromellite anvils and in CaF₂ (8.0 GPa), AgI (9.7 GPa), ZnS (15.0 GPa), GaP (22.0 GPa) using diamond anvils. With the latter was also recorded the baric shift of the ruby R-line in synthetic alexandrite (BeAl₂O₄:Cr³⁺ + 0.21 wt.% Cr₂O₃) under a hydrostatic pressure of up to 8.0 GPa: $d\lambda/dP = 0.282 \pm 0.005$ nm/GPa. The apparatus was tested with diamond anvils for pressures above 30.0 GPa. Figures 3; references 18: 7 Russian, 11 Western. [107-2415]

UDC 536.424.1

DIAMOND CHAMBER TO STUDY EFFECT OF SHEARING STRAIN ON STRUCTURES AND PROPERTIES OF SOLIDS UNDER PRESSURES UP TO 43 GPa

Moscow PRIBORY I TEKNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 84 (manuscript received 3 Nov 83) pp 178-180

BLANK, V.D., KONYAYEV, Yu.S., KUZNETSOV, A.I. and ESTRIN, E.I., Institute of High-Pressure Physics, Troitsk

[Abstract] A test chamber has been built to study solids under high pressure and shearing strain. The anvils are made of natural diamond single crystals or synthetic "cabonado" diamonds. A specimen is placed between the two anvils, usually without a gasket, after the latter have been adjusted by means of a ball hinge into plane parallelism. Pressure is produced by applying a force of up to 15 kN to the plunger through a lever mechanism. Shear is produced by turning one anvil 5-8° with a motor through a speed reducer, at a rate which can be varied from 0.1 to 8.8 deg/min, without significant loss of parallelism with the fixed other anvil. Optical examination and measurements as well as photographic recording are made under an MIN-8 microscope. With natural diamonds used for the anvils, the pressure could be calibrated against the luminescence spectrum of a ruby crystal. The chamber was tested on NaCl+ Al₂O₃:(1 vol.%)Cr³⁺ under pressures up to 43 GPa before and after shear through a 30° angle, without damaging the diamond anvils. The chamber was also used for x-ray examination of bismuth and germanium, namely for determining the pressure dependence of their electrical resistivity and for recording their phase transitions. The authors thank M.I. Yeremets, Ye.S. Itskevich, and A.M. Shirokov for permitting the use of their calibration procedure. Figures 3; references: 4 Russian. [107-2415]

PHOTOMETER FOR MONITORING FILM THICKNESS BY METHOD OF TWO WAVELENGTHS

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 84 (manuscript received 15 Jul 83) pp 205-208

FURMAN, Sh.A. and ELGART, Z.E.

[Abstract] A photometer has been developed for monitoring the thickness of interference-type optical coatings during the deposition process by the method of two wavelengths. It consists of a dichromator with two diffraction gratings, a chopper-modulator disk with a drive motor, a light-emitting diode and a light-activated diode, a synchronizer, an instrument transducer, and a digital voltmeter. Light from a lamp behind an objective lens passes through the test specimen inside the vacuum processing chamber and, upon leaving that chamber, is reflected by a 45°-slant plane mirror into the dichromator with a focusing lens in front. The two photoelectric output signals, which are proportional to the transmission coefficients at the two wavelengths extracted by the dichromator, become equal, and their difference will thus be zero when the film has built up to the required thickness. The instrument error, which depends on the spectral characteristics of the light source as well as on those of the optical channel and the photoreceiver, can be minimized by regulating the sensitivity by means of optical attenuators at the dichromator exit. The electrical circuit of the transducer and the synchronizer for converting a 127 Hz photomultiplier output signal contains six operational amplifiers, two RC filters, two potentiometers, four capacitors, and four electronic switches, all designed to produce a voltmeter reading proportional to the signal difference. The instrument operates on the basis of the relation between transmission coefficient $T_{\lambda}^{(i)}$ at wavelength λ and thickness of the i -th coating layer d_i , which is $T_{\lambda}^{(i)} = 2[A + D \cos(\frac{4\pi}{\lambda} n_i d_i)]^{-1}$ (n_i - refractive index of i -th coating layer, A and D constants determined by the coating structure). Figures 3; references 5: 4 Russian, 1 Western.
[107-2415]

UDC 541.123.2:546.831.17

DEVICE FOR MEASURING PRESSURE OF SATURATED VAPORS OF SUBSTANCES

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 84 (manuscript received 23 Aug 83) pp 212-213

GUBIN, M.M. and SHTEYNER, G.S.

[Abstract] A device has been built for measuring the pressure of saturated vapors by the Langmuir-Knudsen effusion method. The effusion chamber is formed by a thin cup and a diaphragm which covers it on top and also acts as a gasket, each with a welded-on flange around. A small orifice in the diaphragm allows effusion of vapor. A certain amount of test substance is

placed inside the cup, whereupon the cup and diaphragm are weighed before being tightly sealed together by bolting their flanges together. The chamber is then connected vacuum-tightly to a suction pump for evacuation down to 10^{-6} torr. The chamber is then heated to the test temperature and maintained at that temperature while suction pumping continues for a specified length of time. After termination of this process, cup and diaphragm with the remaining substance inside are weighed again. The chamber has a capacity of 140 cm^3 , and the effusion hole is 0.3 mm in diameter and 0.1 mm long. The device was successfully used for study of cadmium vapor; 0.3-0.5 g of powder was held at temperatures of from 200 to 280°C under pressures of from $4.0 \cdot 10^{-4}$ to $220 \cdot 10^{-4}$ torr, correspondingly, for 10 min to 3 h, depending on the temperature. The device was also tested on a high-molecular organic liquid (trimethyl-pentaphenyl-trisiloxane). It was found to give reliable results within the 300-900 K temperature range. Figures 1; tables 2; references: 7 Russian.
[107-2415]

UDC 621.084.2

WIDEBAND PIEZOELECTRIC PRESSURE TRANSDUCER

Moscow. PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 84 (manuscript received 30 Aug 83) pp 214-217

GODONYUK, V.A., ZHURAVLEV, B.V. and SHEDKO, I.P.

[Abstract] A piezoelectric pressure transducer for pressures of up to 100 MPa has been developed, with an operating frequency range from 100 Hz to 1 MHz on the electrical side - sufficiently wide to reproduce pressure profiles of arc discharges with microsecond rise times and millisecond fall times. The sensing element is a disk of TsTS-19 piezoceramic material, 1 mm thick and 5 mm in diameter. It is thermally and electrically insulated from the arc plasma by a compound transmission rod consisting of two quartz crystals 5 mm in diameter and freely sliding inside a teflon sleeve. The 50 mm long waveguide for absorbing acoustic vibrations and thus separating the valid signal from the reflected one consists of brass wires acoustically insulated with epoxy resin and encapsulated into a textolite sleeve with epoxy resin at the other end. A copper housing shields the transducer from electromagnetic interference. The transducer output signal passes through a matching circuit and then a high-impedance voltage divider to a differential amplifier, the latter being shunted by a stabilizing "low" 1 Mohm resistance at the input. A special feature of this transducer is low-frequency compensation by means of a corrective RC-circuit. After calibration of oscillograms, the transducer has a sensitivity of 1 V/MPa over the 10^{-2} -10 MPa range. Its resolution corresponds to the 2 μs maximum rise time of its output signal, with the sensing element located at the end of a shock tube. Figures 3; references: 7 Russian.
[107-2415]

FURNACE FOR TESTING MATERIALS IN AIR AT TEMPERATURES UP TO 1850°C

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 84 (manuscript received 28 Jul 83) pp 217-218

SOTNIKOV, V.Ye., SMIRNITSKIY, A.M., SATANOVSKIY, A.V., BALKEVICH, V.L. and MOSIN, Yu.M., Moscow Institute of Chemical Technology

[Abstract] A tubular high-temperature air furnace with a $\text{La}_2(\text{CrO}_3)_3$ heater element has been developed for testing materials. The electrical resistance of this heater element is 200 ohm at 20°C room temperature and 20-30 ohms at the top temperature. The helical heater is surrounded by three cylindrical layers of refractory thermally insulating materials within a cylindrical metal enclosure: a layer of high-density corundum on the inside and a layer of ShLB-0.4 fireclay on the outside with a layer of KL-1.3 plain corundum in between. The heater is energized from a 220 V - 50Hz power line through a thyristor bank. The furnace temperature is controlled by a high-precision regulator around the heater extension above the lining, with a PR(Pt-Rh) 30/6 thermocouple mounted preferably inside rather than outside the heater coil for faster response and better accuracy. The test tube with a specimen is inserted inside the heater coil, where it can remain for more than 50 h at 1850°C and for short periods at 1900°C. The furnace can be cycled at least 50 times in a row by heating at a rate of 20°C/min and then cooling to 20°C. Refractory materials can be tested in this furnace also with air replaced by an oxidizing atmosphere. Figures 1; references: 2 Russian. [107-2415]

UDC 681.325.22

HIGH-PRECISION HEATING CONTROL MODULE WITH HOOKUP TO 'ELEKTRONIKA DZ-28' MICROCOMPUTER FOR ELECTRICAL RESISTANCE FURNACES

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 84 (manuscript received 14 Dec 82) pp 221-223

FRADKOV, A.I.

[Abstract] A high-precision heating control module has been designed for electrical resistance furnaces operating from a power line through a thyristor bank, with hookup to an "Elektronika DZ-28" microcomputer. It converts an 8-digit binary parallel code to the thyristor conduction angle $\phi = N/2^9 f$ (f - frequency of the line current, $0 \leq N \leq N_{\max}$ - code at microcomputer output busbar) with an error not exceeding 0.4%. A furnace address analyzer-decoder across the control busbar generates a machine synchronizing pulse or a periphery synchronizing pulse. A generator of clock pulses feeds them to a reversible counter both directly and through a $1:2^9$ frequency divider, a plain counter, and a register. Other components include a shaper of two short

pulses upon zero-crossover of the line voltage wave, a shaper of one short pulse upon zero-return of the code in the reversible counter, another register across the microcomputer output busbar, another reversible counter behind it, and an RS-trigger for the thyristor bank loaded by furnace heater elements. The microcomputer can be programmed and, together with the control module, used for gathering, processing, and recording of experimental data during thermoanalytical heating of a 200 W furnace from 0 to 1000°C with a regulation error not larger than 1°C throughout the entire range. The control module can serve up to 16 furnaces simultaneously. Figures 2; references: 2 Russian. [107-2415]

UDC 621.317.42:538.24

TELEVISIONING MAGNETOOPTICAL APPARATUS FOR STUDY OF DOMAIN STRUCTURE OF MAGNETIC MATERIALS

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 84 (manuscript received 25 May 83) pp 155-156

SHAKARYAN, G.G. and VERMISHYAN, G.A., Yerevan State University

[Abstract] A televising apparatus has been built for study magnetic materials, specifically their domain structure, with the capability of producing X300 magnified sharp-contrast images. Magnification is effected in two stages, first X(5-10) optically and then X30 electronically. The light beam from a KGM12-100 or KGM24-150 incandescent halogen lamp passes successively through a condensing lens, a diaphragm, a collimator, and a shutter to a Glan-Thomson polarizer. The polarized light impinges on the flat surface of the test specimen at a 60° angle of incidence, corresponding to the maximum strength of the meridional Kerr effect. The reflected light passes successively through a "Jupiter-9" or "Helios-44" target of a KTP-40 television camera. The image can be photographed with the aid of a video monitor. The apparatus was used experimentally in a study of thin 82%Ni+ 18% Fe Permalloy films with a SiO coating. Figures 2; references 10: 4 Russian, 6 Western. [107-2415]

DETECTION OF CHARGED-PARTICLE PLUGS IN GASEOUS TARGET BY MEANS OF SEMI-CONDUCTOR-TYPE DETECTORS

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 5, Sep-Oct 84 (manuscript received 3 Jun 83) pp 36-40

BINKO, G.F., GORNOV, M.G., DOBRETsov, Yu.P., KIRILLOV-UGRYUMOV, V.G., MALOLETNEV, A.A., MIKAELIAN, A.L., PICHUGIN, A.P., PROTASOV, V.P., SAVELYEV, V.I., SMAKOV, A.Ya., KHOMUTOV, A.A. and SHISHKOV, A.V., Moscow Institute of Engineering Physics

[Abstract] A new reliable method of detecting charged-particle plugs in a gaseous space is proposed which, unlike the conventional anticoincidence method using scintillation detectors, involves measuring the energy of impinging particles with two semiconductor-type detectors. Only particles with an energy so low that they will stop in the target are sampled. This method eliminates background interference caused by plugs in scintillators and is applicable to fast processes as well as slow ones. It has been proved out in an experiment with muons in the synchrocyclotron at the Leningrad Institute of Nuclear Physics (SSR Academy of Sciences). The gaseous target was a Ne+ 2.5% Xe mixture, the xenon forming an electron shell of muonic fluorine. A beam of muonic atoms in Ne and Fe, formed by two magnetic lenses, was passed through a collimator between two monitoring scintillation counters and then through two graphite moderators into the gas chamber with two semiconductor-type detectors: a Si(Au) surface-barrier detector and a Si(Li) lithium-drift detector. The target together with three pairs of scintillation control detectors of an electron telescope, each pair with an aluminum filter-interlayer, were placed inside a set of Helmholtz coils producing a magnetic field. The thicknesses of the two detectors are adjusted, relative to the effective thickness of the target (g/cm^2); the thickness of the Si(Li) detector is made equal to that of the Si(Au) detector when the gas target is thin and equal to the thickness of the Si(Au) detector plus the effective thickness of the gas target when the latter is thick. Figures 5; tables 1; references 8: 6 Russian, 2 Western. [107-2415]

ANALYSIS OF FREQUENCY CHARACTERISTICS OF MULTILAYER CYLINDRICAL SHELLS ON BASIS OF VARIOUS THEORIES

Kiev PRIKLADNAYA MEKhanika in Russian Vol 20, No 12, Dec 84 (manuscript received 24 Nov 83) pp 52-58

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[Abstract] Free undamped vibrations of multilayer circular cylindrical shells are analyzed according to an exact three-dimensional theory of elasticity and according to two approximate two-dimensional theories, namely the Kirchhoff-Love classical theory and the Timoshenko nonclassical theory. It is assumed that such a shell consists of an arbitrary number of layers in rigid contact with one another and each having a uniform thickness. The problem reduces to the system of partial differential equations

$$D\bar{N} - C \frac{\partial^2 \bar{N}}{\partial t^2} = 0 \quad (D - \text{matrix of three- or two-dimensional differentiation operators, } C - \text{inertia matrix, } \bar{N} - \text{sought state vector-function, } t - \text{time}).$$

The nontrivial solution to this system of equations yields the modes and the frequency spectrum of free vibrations as well as their dependence on the relative thickness of the load-bearing layers. The nonclassical theory is found to agree better with the exact theory than does the classical theory. Numerical data on a typical example of an orthotropic triple-layer shell reveal mode sign reversals and low frequency dips at certain ratios of carrier thickness to filler thickness. Figures 4; references 9: 5 Russian, 4 Western (all in Russian translation).

[161-2415]

REPRESENTATION OF MEDIAN SHELL SURFACES BY MONGE SURFACES

Kiev PRIKLADNAYA MEKhanika in Russian Vol 20, No 12, Dec 84 (manuscript received 6 Jan 83) pp 70-75

SAVULA, Ya.G., Lvov State University

[Abstract] Parametrization of median shell surfaces by representing them as Monge surfaces is proposed; a Monge surface is formed by a planar generatrix curve which moves along a generally spatial directrix curve while it remains fixed in the plane normal to the latter. The simple case of a smooth generatrix is considered, assuming moreover a planar directrix. Shallow surfaces are described on this basis; a typical example is a surface of revolution with a circular parallel as directrix and a meridian as generatrix. A parametrization procedure is shown which simplifies the expressions for Lamé coefficients and principal curvatures. Calculations are based on the Menier

theorem and use of grids of biquadratic elements. Figures 3; references 5: 3 Russian, 2 Western (both in Russian translation).
[161-2415]

UDC 539.3:534.1

SPECIAL REVERSE PROBLEM FOR CYLINDRICAL SHELL OF VARIABLE THICKNESS

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 20, No 12, Dec 84 (manuscript received 9 Nov 83) pp 75-80

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[Abstract] The reverse state-of-stress and deflection problem of optimization is considered for a cylindrical shell of variable thickness under an axisymmetric load, with the thickness distribution as the control function under geometrical constraints and with strength as the design criterion. The formulation of this problem is to determine the longitudinal thickness profile with which the deflection function will be the closest uniform approximation of the prescribed deflection curve. The problem is treated as an infinite-dimensional one and, accordingly, replaced with an approximating sequence of problems in nonlinear programming. The latter is solved by finding the thickness vector rather than the thickness function and constructing with it a piecewise-linear continuous control. This has been done for an isotropic cylindrical shell under uniform external pressure with rigidly clamped or hinge supported ends, and the thickness profile is found which minimizes the deflection function. Comparison with a shell of uniform thickness and the same weight indicates that the latter is only slightly suboptimum in this respect. Figures 4; references: 7 Russian.
[161-2415]

UDC 539.3

WAVE PROCESSES DURING FLEXURAL VIBRATIONS OF BEAMS UNDER DEFORMATION

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 20, No 12, Dec 84 (manuscript received 18 Jan 83) pp 95-100

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[Abstract] Flexural vibrations of a homogeneous beam of finite length with distributed parameters including viscous damping under a strain proportional to the deformation rate are analyzed in terms of wave processes. The corresponding differential equation of motion is formulated according to Bernoulli's theory and solved in complex form, by expressing the flexural modes as superpositions of two wave pairs: a forward traveling one and a backward traveling one. Every complete reflection at either beam end results

in two return waves. The imaginary part of the phase velocity represent the rate of change of the constant-phase surface normally to the direction of wave propagation. The beam impedances with respect to the waves become zero in the case of free vibrations, but not in the case of forced vibrations at any excitation frequency. Figures 4; references 3: 1 Czechoslovak (in Russian translation), 2 Western.
[161-2415]

UDC 531.74

DETERMINING ORIENTATION OF OBJECT WITH FIXED POINT

Kiev PRIKLADNAYA MEKhanika in Russian Vol 20, No 12, Dec 84 (manuscript received 28 Oct 82) pp 101-105

TKACHENKO, A.I., Institute of Cybernetics, UkSSR Academy of Sciences, Kiev

[Abstract] An undeformable object is considered which rotates about its one fixed point in contact with the earth surface. The problem of determining its orientation from the readings of a tachometer and a triaxial accelerometer is formulated in quaternions, taking into account the rotation of earth and then assuming that the Euler angles which define the orientation of the orthonormalized object basis relative to the orthonormalized earth basis are known at any instant of time from the beginning to the end of the rotation of the object. The problem is solved by operating over vector and scalar components of the corresponding two quaternions, down to second-order smallness. The accuracy of the determination depends on the unknown vectors in the tachometer and accelerator basis, which are assumed to be small and constant, as well as on the unknown orientation of that basis relative to the object basis. They are estimated by solving the excess system of equations for the quaternion components, using any appropriate method such as the recurrence least squares method. The entire process is demonstrated using the example of measurement with the sensitivity axes of both instruments deviating from orthogonality. References 6: 4 Russian, 2 Western (both in Russian translation).
[161-2415]

STABILITY OF SHELLS OF REVOLUTION WITH SMALL DEVIATIONS FROM CYLINDRICAL SHAPE

Kiev PRIKLADNAYA MEKhanika in Russian Vol 20, No 12, Dec 84 (manuscript received 5 Dec 83) pp 106-108

BABICH, D.V. and DERIGLAZOVA, L.A., Institute of Mechanics, UkSSR Academy of Sciences, Kiev

[Abstract] The stability of shells of revolution with deviations from ideal shape is analyzed by relating these deviations to the geometrical parameters of the median surface, in accordance with the fundamental relations of differential surface geometry. The effect of such deviations on the critical load for asymmetric loss of stability is evaluated on this basis by the variation-difference method, using the Trefftz variational principle with a discrete approximation to the functional in the variational equation. As a specific example is considered an isotropic cylindrical shell. Deviations from the ideal median surface around parallels are stipulated as small perturbations of the radius. The geometrical parameters, namely curvatures and Lamé coefficients, are calculated before the subcritical state of stress can be determined from the equations of zero-moment theory. For a cylindrical shell rigidly clamped at the ends and under an axial compression pressure, particularly, the circumferential forces are found to be compressive or tensile depending on the sign of the meridian curvature. Calculations for short and thin shells with three typical patterns of generatrix distortion, made of a material with a ratio of Young's modulus to shear modulus of $E_{12}:G_{12} = 1:0.385$ and a Poisson's ratio $\nu = 0.3$, reveal that the magnitude of the critical load depends on both mode and amplitude of shape distortion. Figures 2; references: 6 Russian.
[161-2415]

NATURAL VIBRATION MODES OF IMPERFECT CONICAL SHELLS

Kiev PRIKLADNAYA MEKhanika in Russian Vol 20, No 12, Dec 84 (manuscript received 28 Dec 83) pp 109-112

FIALKO, S.Yu.

[Abstract] In order to reconcile theoretical and experimental data pertaining to natural vibrations modes of ideal and real shells of revolution, respectively, the theoretical analysis is extended so as to take into account shape imperfection. As an example is considered a conical frustum shell with non-axisymmetric initial deflection $w_0 = b \sin \frac{\pi \alpha_1}{L} \cos(n_0 \alpha_2)$ (b - amplitude of deflection, L - length of generatrix, α_1 - meridional coordinate, α_2 - parallel coordinate, n - number of waves around circumference), $n_0 = 2$ being a typical

case. The behavior of such a shell is described by a system of linear equations in components of the state of strain; this system is derived by linearization from the geometrically nonlinear hybrid system of equations. The solution and subsequent numerical calculations reveal that such an initial deflection produces vibration modes with different numbers of nodal lines at the two shell bases. This is attributed to the fact that the resulting circumferential vibrations are not simple but compound harmonic ones. Without

initial deflection the vibration modes are $w(\alpha_1, \alpha_2) = w^*(\alpha_1) \cdot \begin{cases} \cos(n\alpha_2) \\ \sin(n\alpha_2) \end{cases}$.

When n_0 is a whole multiple of n , then there are two different vibration modes at corresponding different frequencies, the nodal lines of one coinciding with and those of the other lying between the nodal lines of initial deflection. Figures 4; references 8: 5 Russian, 3 Western.
[161-2415]

UDC 539.3

NONAXISYMMETRIC DEFORMATION OF FLEXIBLE TOROIDAL SHELL WITH ELLIPTIC CROSS-SECTION

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 20, No 12, Dec 84 (manuscript received 28 Dec 83) pp 112-115

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[Abstract] Nonaxisymmetric deformation of a flexible thin toroidal shell with elliptic cross section by a surface load is analyzed, allowing the shell thickness to vary generally in two coordinate directions. The corresponding boundary-value problem is formulated in the quadratic approximation of the geometrically nonlinear theory. The resulting system of nonlinear partial differential equations with variable coefficients and with the meridional arc length as an integration variable is solved by the method of straight lines, assuming that the resolvent functions and the variation of coefficients are sufficiently smooth around the circumference. A numerical solution is obtained by the stable method of discrete orthogonalization according to the Runge-Kutta scheme so as to avoid local instabilities, and using the algorithm of linear integration so as to operate with a constant data volume rather than with a successively doubling one. The procedure was programmed in FORTRAN for YeS computers and a BESM-6 high-speed one. Calculations were made for shells with the shape of the cross-section varied by varying the ratio of semiaxes a/b from 4.909 to 9 but keeping their product constant at $ab = 54$, and with three different sets of constraints around the contours described by two semiaxes: 1) rigid clamping around both contours; 2) rigid clamping around the contour described by the major semiaxis and hinge support around the contour described by the minor semiaxis; 3) hinge support around both contours. The results reveal that the effect of nonlinearity on the stressed-strained state becomes stronger as the ratio a/b is

increased. Deflections increase and stresses decrease as rigid clamping is replaced with hinge support; the effect of nonlinearity is stronger in the latter case and particularly so with respect to deflections. Figures 3; tables 1; references 6: 5 Russian, 1 Western (in Russian translation). [161-2415]

UDC 539.3

WAVES IN STRATIFIED MEDIA WITH CURVED INTERFACES

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian No 1, Jan-Feb 85 (manuscript received 19 Apr 84) pp 97-103

ARTIKOV, T.U., Tashkent

[Abstract] Wave processes in a multilayer porous medium with curved interfaces which can be described by coordinate equations $y = f_i(x, z)$ and with a liquid filler between the two half-spaces are analyzed, considering the case of an obliquely incident plane harmonic wave of a given frequency at the interface with the lower half-space. The wave field at any point in the medium is determined from the M.A. Biot equations of motion for porous media; these equations in stresses are converted into equivalent equations in displacements by introducing the velocity potential for each layer. These equations are solved under constraints of stress and velocity continuity as well as mass flux conservation at both boundaries of the medium. Since an analytical solution is almost impossible for the general case, a numerical solution by the perturbation method with use of matrix calculus is proposed instead. The algorithm has been programmed in FORTRAN for a BESM-6 high-speed computer, similar to the known algorithms for plane or polygonal interfaces. The results are demonstrated on a typical "layer" in the form of a conical inclusion. The method of analysis and solution can be applied to seismology; the results indicate that the effect of ground surface unevenness becomes negligible when the ratio of surface displacement to quake wavelength is less than 3%. Figures 3; references 7: 3 Russian, 4 Western. [189-2415]

UDC 539.3

PROPAGATION OF ELASTIC WAVES THROUGH MULTILAYER STRIP

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian No 1, Jan-Feb 85 (manuscript received 9 Mar 83) pp 104-109

VASILYEV, V.V. and SIBIRYAKOV, A.V., Moscow

[Abstract] An infinitely long strip of finite width consisting of several horizontal layers of generally unequal thicknesses is considered under a

normal pressure load which acts on the upper surface, is nonuniformly distributed over the width of the strip, and varies in time, while the lower surface of the strip between free supports along both edges remains load-free. The propagation of waves under such a load is analyzed according to the theory of elasticity, considering the stressed state to be a three-dimensional one. The corresponding system of equations of motion is solved for appropriate initial and boundary conditions, with the aid of the Laplace-Carson transformation and subsequent inverse transformation for obtaining the solution in the form of a series. The procedure and results are demonstrated on a double-layer strip of a composite material with width-wise reinforcement, an organoplastic protective layer under the load on top of a boron-plastic strength layer, under a square microsecond pulse of uniformly distributed pressure. In another example, a triple-layer strip with a light-weight filler between a composite plastic lower layer and a metal upper layer, also under a square microsecond pulse of external pressure, it is demonstrated how the stress level can be reduced by proper modification of the stack structure and possibly addition of more layers without changing its total thickness. Figures 4.
[189-2415]

UDC 539.214:539.374

PARAMETRIC OPTIMIZATION OF PLASTIC CYLINDRICAL SHELLS WITH GEOMETRICAL NON-LINEARITY

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian
No 1, Jan-Feb 85 (manuscript received 16 Dec 82) pp 138-146

LELLEP, Ya.A., Tartu

[Abstract] Design optimization of a closed circular cylindrical shell under internal pressure is considered; its ideally triple-layer lateral wall consists of two sheaths separated by a filler and its ends are arbitrarily constrained. Both the length of the shell and its total wall thickness are fixed. The problem is to optimally space additional reinforcing hoops along the wall and to match the allowable pressure range with the thickness of both sheath so as to minimize the functional which characterizes the optimality criterion. The shell is assumed to be a Trask-St.Venant body of rigid-plastic material, which adds two other constraints in accordance with the corresponding geometrically nonlinear theory of plasticity. The analysis and calculations are based on the corresponding strain theory of plasticity, where the yield surface forms a closed polyhedron and can be described by the equation of a plane in the space of generalized stresses. The problem is formulated as a variational one of optimal control with phase constraints and is solved by the author's earlier method for plastic beams beyond the yield point, for which the minimizable functional must be extended according to the V.A. Troitskiy method. Figures 2; references 10: 4 Russian, 1 Polish (in Russian translation), 5 Western (1 in Russian translation).
[189-2415]

PRECESSION OF NATURAL VIBRATION MODE IN SPHERICAL SHELL DURING ROTATION

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian
No 1, Jan-Feb 85 (manuscript received 18 May 84) pp 147-151

ZHURAVLEV, V.F. and POPOV, A.L., Moscow

[Abstract] A hemispherical shell with a free edge is considered when rotating about its axis of symmetry at a generally variable speed. The vibrations of such a shell are described by the V.V. Novozhilov system of three resolvent equations. These are reduced to two systems of ordinary differential equations for the amplitudes of vibrations, both containing the relative speeds of traveling natural circumferential modes and only one containing their frequencies. The quadratic characteristic equation has only one positive root, which yields the precession speed of a natural mode of plane-flexural or torsional vibrations. Calculations for the fundamental mode reveal that its speed is only slightly dependent on the Poisson ratio of the shell material. The ratio of mode speed to shell speed is completely independent of the shell speed, which means that the mode axis does not depart from its position relative to certain points on the shell equator as the shell speed varies, provided that the shell speed remains far below the critical. The analysis for the special case of constant low speed of shell rotation is extended to the general case of an arbitrarily variable speed. Figures 1; references 8: 7 Russian, 1 Western.
[189-2415]

RELATIVE MOTION OF SYMMETRIC SOLIDS ABOUT STATIONARY POINT

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian
No 1, Jan-Feb 85 (manuscript received 3 May 83) pp 53-58

BOLOTINA, N.Ye. and VILKE, V.G., Moscow

[Abstract] The motion of two symmetric solids about a stationary point is considered, specifically motion produced by a moment of force proportional to the difference between their angular velocities. One body is assumed to be a sphere inside the other, a spherical shell, with a viscous fluid filling the narrow gap between them. The problem is formulated in three systems of coordinates, one stationary and two rigidly tied to and moving with another body each. The motion is analyzed on the basis of the change-of-energy theorem, according to which at an infinite time the two bodies will cease to move relative to each other and will continue to move as a single body. The evolution of this motion is first described by approximate equations in canonical Andoirier [spelling uncertain] variables and the Hamiltonian, taking into account the work of dissipative forces. These equations are then

simplified, in "action" variables and "slow" angular coordinates. Solution of the problem reduces to testing the three roots of the characteristic equation. One of them is zero, by virtue of momentum conservation, and the signs of the other two determine whether the steady-state motion is stable or unstable. This problem is a special case, generally the two bodies not being dynamically similar and not only rotating but engaged in other steady motion such as regular precession when their angular velocities are equal. Figures 2; references: 7 Russian. [189-2415]

UDC 539.376

VIBRATIONS AND HEATUP OF VISCOELASTIC RECTANGULAR PRISM AND FINITE CYLINDER UNDER KINEMATIC EXCITATION

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 20, No 10, Oct 84 (manuscript received 20 Sep 83) pp 45-52

SENCHENKOV, I.K. and CHERVINKO, O.P., Institute of Mechanics, UkSSR Academy of Sciences, Kiev

[Abstract] The spectrum of resonance modes and frequencies is calculated for a rectangular prism under kinematic excitation at two opposite ends and with an otherwise load-free surface. The solution of the corresponding wave equations is extended, by the superposition method, from an elastic material to a linearly viscoelastic one, and the effect of viscosity is taken into account in this way. The effect of vibrational heatup is evaluated by calculating the temperature field as the solution to an appropriate boundary-value problem for the equation of transient two-dimensional heat conduction and thermal diffusion; this equation can be readily solved by the method of finite differences. The procedure is applicable to the special and practically more important case of a finite cylinder. Figures 5; references: 7 Russian. [161-2415]

UDC 539.3:534.1

NATURAL VIBRATIONS OF CYLINDRICAL SHELL UNDER INITIAL EXTERNAL PRESSURE NONUNIFORMLY DISTRIBUTED OVER CIRCUMFERENCE

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 20, No 10, Oct 84 (manuscript received 15 Mar 83) pp 53-59

KUKUDZHANOV, S.N., Institute of Mathematics, GSSR Academy of Sciences, Tbilisi

[Abstract] Natural radial vibrations of a cantilever cylindrical shell are analyzed, specifically a shell which is hinge-supported at one end and reinforced by a perfectly stiff ring at the free other end. The object is to

determine the effect of initial external pressure, a pressure nonuniformly distributed over the circumference, on the resonance modes and frequencies. The initial external pressure is assumed to be an even function of the

angular cylindrical coordinate $q(\phi) = q^0 \sum_{p=0}^N \alpha_p \cos(p\phi)$, and the deflection is

sought in the form of a double series $w = e^{j\omega t} \sum_{mn,k} A_{mn,k} \sin \frac{m-R}{L} \cos(n_k \phi)$ (R-

radius of shell, L- length of shell). The problem is solved by the Bubnov-Galerkin method, with the indices of the coordinate functions sought for the optimum initial approximations not a priori fixed but forming some not a priori known sequence. The resulting homogeneous system of linear algebraic equations for the coefficients $A_{mn,k}$ was solved numerically on a computer and, on this basis, the frequency-pressure characteristics of thin shells with radius-to-thickness ratios $R/h = 170-800$ and length-to-radius ratios $L/R = 1-4$ were evaluated for the two special cases $\alpha_0 = 1$, $\alpha_1 \neq 0$, $\alpha_p = 0$ and $\alpha_0 = 1$, $\alpha_2 \neq 0$, $\alpha_p = 0$ (p denoting "all others"). Figures 5; references 4: 3 Russian, 1 Western.

[161-2415]

UDC 539.3

STABILITY OF MULTILAYER CYLINDRICAL SHELL UNDER EXTERNAL PRESSURE

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 20, No 10, Oct 84 (manuscript received 21 Feb 83) pp 59-64

ANIDREYEV, A.N., Kemerovo State University

[Abstract] An orthotropic multilayer cylindrical shell on free supports at the ends and under a uniformly distributed external pressure is analyzed for the stability of its nonzero-moment state. The calculations are based on the corresponding equations of neutral equilibrium and take into account the axial symmetry of the subcritical state. With the boundary conditions stipulated in variations, the problem is solved by Fourier series expansion of functions which characterize the subcritical state and the modes of stability loss. The eigenvalues of high-order matrices for high-accuracy results are evaluated by numerical methods. Six critical loads were determined for a triple-layer shell, each according to a different static or kinematic hypothesis. All four static hypotheses yield approximately the same result, i.e.: 1) uniform stressed-strained state of thin element; 2) broken-line hypothesis; 3) distributions of transverse stress components τ_{13} , τ_{23} , σ_{33} and, independent of them, strain components ϵ_{33} over stack thickness; 4) quadratic distribution of stress components τ_{13} , τ_{23} over stack thickness. The two kinematic hypotheses are inadequate for shells with layers of appreciably different stiffnesses, i.e.: 1) rigid normal lines; 2) straight line for entire stack. The accuracy of predicting the critical load is improved greatly by taking into account transverse shear and only slightly by taking into account normal compression. Disregarding the nonuniformity of subcritical force

distribution leads to large errors for short shells and to not so large errors for compliant shells. Tables 3; references 20: 19 Russian, 1 Western. [161-2415]

UDC 539.3

CYLINDRICAL SHELL WITH SLIT UNDER TENSION

Kiev PRIKLADNAYA MEKhanika in Russian Vol 20, No 10, Oct 84 (manuscript received 30 Jun 83) pp 64-69

DYSHEL, M.Sh., Institute of Mechanics, UkSSR Academy of Sciences, Kiev

[Abstract] Thin cylindrical shells made of AMg6M aluminum alloy with a narrow circumferential slit were tested in a TsD-10/90 tensile machine, with no load acting on the edges of the 0.2 mm wide slit. Normal deflections in the vicinity of the slit were measured with pneumatic strain gauges. The stress-strain curves for shells 120 mm in diameter and 0.3-0.46 mm thick with slits 20-70 mm long reveal a typical linear dependence of deflection on applied tension over a wide initial load range. The deflection is larger when the slit is longer, and when the shell is thinner, it is larger than the shell thickness even below the yield point. The deflection is maximum at the center of the slit; the shell buckles outward along the edges of the slit, decrease toward the tips of the slit and the shell buckles inward along the unslit portion of the circumference. Loading beyond the linear range results in cracking beyond the tips of the slit in the same direction, up to complete fracture around the circle. The cracking and fracture kinetics in shells of 70-250 mm diameters under monotonically increasing tension, monitored with photoresistors and by high-speed photography, reveal a long phase of steady subcritical crack propagation at a constant rate after an initial noncracking range and followed by supercritical avalanche breakdown. For quantitative analysis of this process, the dependence of the length of a crack on the length of time was approximated as a piecewise-linear function. In addition, slit cylindrical shells were tested under tension while in continuous contact with a stiff parallel cylinder on the outside along a generatrix passing through the unslit portion. In this case the absence of normal deflection and buckling alters the deformation kinetics and the fracture pattern into those characteristic of reinforced shells. Figures 5; tables 1; references 6: 5 Russian, 1 Western. [161-2415]

OPTIMUM CONTROL OF SYSTEM WITH TWO PENDULA

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian
No 1, Jan-Feb 85 (manuscript received 31 May 82) pp 37-44

NGUEN VAN DINH, Hanoi/VIETNAM

[Abstract] A system consisting of two pendula is considered, its motion being describable by three differential equations $\ddot{x} = \dot{v} = u(t)$, $\ddot{\phi} + \phi = u(t)$, $\ddot{\psi} + 4\psi = u(t)$, where $-1 \leq u(t) \leq 1$ (x, v - displacement and velocity of horizontally moving pivot; ϕ and ψ - deflection angles of the two pendula having a given natural frequency each; $u(t)$ - acceleration of pivot as control function). Two control functions $u(t)$ optimum with respect to speed are sought for this system. The first one will shift the system from its initial equilibrium state to its final equilibrium state in the minimum time. The second one will switch the system from its initial equilibrium state to its final state of translatory motion. Both problems are solved and the control functions are found analytically. Three conditions are required for optimality in each case and must be verified. Two of them are found to be obviously satisfied and the third one, satisfying Pontryagin's maximum principle, is rigorously proved on the basis of two pertinent theorems. Figures 5; references: 6 Russian.
[189-2415]

INDUCED VIBRATIONS AND HEATUP OF VISCOELASTIC HOLLOW CYLINDER OF FINITE LENGTH UNDER KINEMATIC EXCITATION

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 20, No 11, Nov 84 (manuscript received 20 Sep 83) pp 30-35

SHEVCHENKO, A.Yu., SENCHENKOV, I.K. and CHERVINKO, O.P., Institute of Mechanics, UkSSR Academy of Sciences, Kiev

[Abstract] A hollow viscoelastic cylinder of finite length and under internal pressure is considered; concern focuses on the induced vibrations and attendant heatup of it as a result of harmonic kinematic excitation at its ends. The corresponding boundary-value problem for the equations of elasticity and heat conduction is solved by the superposition method. The condition for the existence of a nontrivial solution yields a transcendental equation whose roots have already been tabulated. Analysis of the solution for the unknown variables is facilitated by utilizing their asymptotic behavior and refining the method of reduction. The displacement, stress and temperature fields were calculated for a typical rubber-metal vibration isolator with IRP-1347 rubber as the viscoelastic component. Figures 4; references: 4 Russian.
[161-2415]

NATURAL VIBRATION MODES OF REINFORCED CONICAL SHELLS

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 20, No 11, Nov 84 (manuscript received 7 Sep 83) pp 51-55

FIALKO, S.Yu., Institute of Mechanics, UkSSR Academy of Sciences, Kiev

[Abstract] Natural vibrations of thin closed conical frustum shells with reinforcing hoops and stringers are analyzed, assuming that all hoops and stringers are one-dimensional elements subject only to flexure in one plane. Each hoop bends in the plane of its axis. Each stringer bends in the plane passing through its axis and the median sheath surface. The analysis is based on the discrete model of an orthotropic structure. Calculations are based on cooperative work of sheath and reinforcement. The corresponding differential equations for the sheath and the reinforcing elements are transformed into central-difference equations of second-order precision, which reduce to a system of linear algebraic equations for the behavior of the given model. Solution of these equations for conical structures with two mutually orthogonal planes of symmetry covers the entire frequency spectrum under all possible combinations of boundary conditions to the left and to the right of the symmetry axis and antisymmetry axis. Numerical calculations are made for a characteristic structural element with circular edges between two neighboring hoops and straight edges between two neighboring stringers. The results reveal that the vibration modes vary continuously under an increasing axial load so that the load dependence of the vibration frequency is more intricate than the classical simple relation for "fixed" modes. Figures 4; tables 1; references: 2 Russian.
[161-2415]

OPTIMUM DESIGN OF TRIPLE-LAYER PLATES AND FLAT SHELLS FOR MINIMUM WEIGHT

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 20, No 11, Nov 84 (manuscript received 14 Oct 83) pp 103-107

PANTELEYEV, A.D., Institute of Mechanics, UkSSR Academy of Sciences, Kiev

[Abstract] The problem of designing triple-layer rectangular plates and flat shells for strength with minimum weight under geometrical constraints is solved, first analytically and then numerically, assuming a symmetric structure. The problem is formulated in the four-dimensional energy space and Sobolev variables, specifically for a bilinear deformation mode. The problem is reduced to the problem of optimal control. An analytical solution is obtained by the methods of penalty function and coordinate descent. An approximate numerical solution, for the strength criterion or any other criterion with lower bound, is obtained by the Ritz method with bicubic

splines. A typical final design of a plate resulting from variation of nine parameters is compared with a plate of uniform thickness. The design with piecewise-uniform thickness achieves a more economical use of materials, but also moves the stress levels closer to the permissible limit. Figures 3; references 8: 7 Russian, 1 Western (in Russian translation).
[161-2415]

UDC 539.4

COMBINING NUMERICAL ANALYSIS AND EXPERIMENT FOR DETERMINATION OF STRENGTH OF GLASS SHELLS UNDER LOCAL STATIC LOAD

Kiev PROBLEMY PROCHNOSTI in Russian No 1, Jan 85 (manuscript received 19 Jan 84) pp 87-90

KUDRYAVTSEV, B.A., PARTON, V.Z. and SENIK, N.A., State Scientific Research Institute of Glass, Moscow

[Abstract] Numerical analysis and experiment are combined to determine the strength of thick-walled glass shells and thus predict their reliability and life under a local static load. In this case the theory of elasticity is inadequate for such a determination on the basis of calculations alone and the nonuniform stressed-strained state makes such a determination on the basis of measurements alone inaccurate. Effective combining of numerical analysis and experimental data is demonstrated on a quasi-hemispherical glass dome under a static load acting at the apex point. The numerical part involves solution of the corresponding axisymmetric problem by the finite elements method. This has been done according to the SPRINT program with variable grids on a YeS-1040 computer for a nominally 15 mm thick shell made of MKR-1 glass (Young's modulus $E = 71,000$ MPa, Poisson's ratio $\mu = 0.19$). Rough calculations with a grid of 5-12 layers were followed by fine calculations with 3661 finite elements on a grid with 1952 nodes. Included was also the effect of thickness nonuniformity on the stress distribution. Calculations for three different thicknesses with subsequent cubic rather than linear interpolation have yielded a stress-thickness curve (polynomial) subject to experimental verification. The experimental part involves testing 10 specimens in a UMM-5 universal machine and measuring strains in the vulnerable zone with short-base (1 mm long) KF5P1 foil gauges. Tests with stepwise static loading till fracture confirmed the theoretical location of fracture on the inside pole surface under the load point. The mean relative error of a linear stress-load relation, on the basis of this agreement, is only 1.454% and has a standard deviation of 9.73%. Figures 3; tables 1; references: 3 Russian.
[182-2415]

AXISYMMETRIC CONTACT INTERACTION OF CYLINDRICAL SHELL AND ELASTIC OR RIGID HOUSING

Kiev PROBLEMY PROCHNOSTI in Russian No 1, Jan 85 (manuscript received 14 Oct 83) pp 90-96

KRZYS, W., and MOC, A., Cracow University, POLAND

[Abstract] An engineering problem in the design and operation of hydraulic presses, namely axisymmetric contact interaction of a cylindrical shell and its housing, is analyzed by the method of variational inequalities with finite differences. The corresponding differential equations are formulated in accordance with the applicable small-strain Timoshenko theory of shells. The shell is in an either elastic or rigid housing longer than the shell on both sides, under a radial load continuously distributed over the middle zone and discretely concentrated but denser toward the ends. The very ends of the shell are assumed to be free of constraints. The results of the solution indicate that the maximum shell deflection and the widths of the contact zones depend on the stiffness of the housing, and that increasing the stiffness narrows the contact zones while as well as decreases the maximum shell deflection. A rigid housing corresponds to one with infinite stiffness, and an elastic one is found to approach this case, a free shell without constraint in a housing with zero stiffness representing the far other extreme case. Figures 6; references 15: 10 Russian, 1 Polish, 4 Western. [182-2415]

UDC 621.438.001.24+621.165.001.24

DESIGN AND EVALUATION OF AUTOMATIC SAFETY DISK

Moscow ENERGO MASHINOSTROYENIYE in Russian No 2, Feb 85 pp 9-12

VISHNYAKOV, G.V., engineer, SARANTSEV, K.B., engineer, and RYBIN, P.A., candidate of technical sciences

[Abstract] An automatic safety disk for preventing excessive turbine overspeed has been developed as a more reliable and accurate alternative, especially at higher nominal speeds, than the existing safety ram. Another advantage over a ram is a longer life expectancy; that of a ram does not exceed 10-15 or 300-400 cycles, depending on whether the ram is made of VTE-1 titanium alloy with nickel-phosphate surface coating or of 34CrMo steel. The main component of the disk device is a leaf spring made of 60S2A strip steel, mounted on the turbine shaft against a shoulder and carrying 12 governor weights spaced uniformly around a concentric circle. The weights are each bolted on with nuts and channel washers on both sides. The spring is keyed to the turbine shaft, to prevent slippage, and preloaded by a threaded retaining ring. Such a spring was tested on an air turbine with a speed

reducer, under steady-state and transient conditions with the turbine running forward or in reverse. The data provided essential design guidelines. Accordingly, the ratio of outside diameter to inside diameter should be within the $1.85 < D_o/D_i < 2.15$ range, and the diameter of the weight circle should be $D_w = (D_o + D_i) \log D_o/D_i$. After the flat blank disk has been given its initial deflection in a die, it should be heat-treated first at 860°C for 4 h and then at 420°C for 4 h with subsequent oil cooling to a final hardness of 32-37 Rockwell C. Then a ratio of initial spring deflection to spring thickness within the $1.72 < H/h < 1.92$ range will ensure a life of at least 1200 cycles at 182 rpm in forward and 125 rpm in reverse rotation. The total mass of all weights m and the distance r from their center to the axis of symmetry of the spring cross-section needed at a given forward turbine speed are found from their product mr , which depends on the spring dimensions and on the density of the spring and weight material. The spring design must then be checked for maximum stresses. The 4-5% discrepancy between experimental performance data and theoretical predictions based on this design procedure is acceptable. Figures 4; tables 1; references 6: 4 Russian, 2 Western. [193-2415]

UDC 621.311.25:621.039:658.523

INSTALLATION OF CORROSION PROTECTION, SPECIAL COATINGS AND THERMAL INSULATION

Moscow ENERGETICHESKOYE STROITELSTVO in Russian No 11, Nov 84 pp 12-14

FENIK, B.S., engineer, and DUNAYEV, V.B., engineer

[Abstract] Facilities have been designed and built for installation of corrosion protection and thermal insulation in nuclear power plants, specifically those with RBMK-1000 MW graphite-water channel reactors. The workshops for this in the Chernobyl AES have been laid out and subsequently expanded since 1977 for most effective general material handling and special processing such as deposition of special coatings. Facilities include means of transportation and warehouses. The protective work done has accordingly increased substantially from year to year. The chemical protection system and the thermal insulation system have been adapted to mechanization and higher level of industrialization, introduction of more efficient and more economical new materials and equipment being an important factor. Figures 1; tables 2. [175-2415]

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